FIRST YEAR
ENVIRONMENTAL BASELINE REPORT
VOLUME 2

FEDERAL PROTOTYPE OIL SHALE
LEASING PROGRAM
TRACTS U-a and U-b
UTAH
WHITE RIVER SHALE PROJECT

TN
859
.U82
W4185
1976
v.2
c.3

vtn

BLM Library
D-553A, Building 50
Denver Federal Center
P. O. Box 25047
Denver, CO 80225-0047

TN
859
.U82
W4185
1976
v.2
c.3

TABLE OF CONTENTS

Volume 2 Page

IV. BIOLOGICAL RESOURCES

A. Vegetation IV-1
  1. Vegetation Mapping IV-2
  2. Community Structure and Composition . . IV-2
    a. Objectives IV-2
    b. Methodology IV-6
    c. Summary of Results IV-7
    d. Conclusions IV-26
    e. Work Scheduled IV-27
  3. Phenological Characteristics IV-27
    a. Objectives IV-27
    b. Methodology IV-27
    c. Summary of Results IV-27
    d. Conclusions IV-28
    e. Work Scheduled IV-28
  4. Productivity IV-28
    a. Objectives IV-28
    b. Methodology IV-28
    c. Summary of Results IV-29
    d. Conclusions IV-34
    e. Work Scheduled IV-39
  5. Ancillary Environmental Factors and Observations IV-39
    a. Root Growth IV-39
    b. Vegetation in Relation to Soil Salinity IV-40
    c. Work Scheduled IV-47
B. Terrestrial Vertebrates IV-48
  1. General Sampling IV-49
    a. Objectives IV-49
    b. Methodology IV-49
    c. Mammals IV-50
    d. Birds IV-63
    e. Reptiles and Amphibians IV-83
  2. Special Studies IV-89
    a. Mule Deer IV-89
    b. Predators IV-98
    c. Amphibians and Reptiles IV-101
    d. Raptors IV-113
    e. Waterfowl IV-118
    f. Beaver IV-121
    g. Livestock IV-123
  3. Non-scheduled Sampling IV-126
  4. Work Scheduled IV-127

TABLE OF CONTENTS (Cont.)

Volume 2 (Cont.) Page

C. Terrestrial Invertebrates IV-130
  1. Objectives IV-130
  2. Methodology IV-130
  3. Summary of Results IV-130
  4. Conclusions IV-141
  5. Work Scheduled IV-141
D. Aquatic Biology IV-142
  1. Objectives IV-142
  2. Methodology IV-143
  3. Summary of Results IV-143
    a. Habitat IV-145
    b. Aquatic Macrophytes IV-145
    c. Periphyton IV-146
    d. Plankton IV-149
    e. Macroinvertebrates IV-152
    f. Fisheries IV-164
  4. Conclusions IV-168
  5. Work Scheduled IV-169
E. Microbiology IV-170
  1. Objectives IV-170
  2. Methodology IV-170
  3. Summary of Results IV-171
    a. Numbers of Microorganisms IV-171
    b. Dehydrogenase Activity IV-171
    c. Proteolytic Activity IV-175
    d. Respiration IV-179
    e. Water Potential and Water Content. . . . IV-179
    f. Nitrification Potential IV-180
    g. ATP Concentration IV-180
    h. Nitrate Values IV-180
    i. Organic Carbon and Nitrogen IV-183
    j. Nitrogen Fixation IV-183
    k. Total Ammonium Nitrogen IV-183
  4. Conclusions IV-184
  5. Work Scheduled IV-185
F. Ecological Interrelationships IV-185
  1. Desert Ecosystems IV-185
  2. Components of the Tract's Ecosystems . . IV-186
    a. Climate IV-186
    b. Soils IV-187
    c. Microbiology IV-188
    d. Plants IV-189
    e. Invertebrates IV-190
    f. Vertebrates IV-191
    g. Aquatics IV-193

GLOSSARY IV-195

REFERENCES IV-198

TABLE OF CONTENTS (Cont.)

Volume 2 (Cont.) Page

V. SOILS AND GEOLOGY

A. Soils V-1
  1. Objectives V-1
  2. Methodology V-1
  3. Summary of Results V-2
    a. Soil Survey V-2
    b. Soil Formation V-20
    c. Soil Classification V-22
    d. Laboratory Analysis of Soils V-24
    e. Use and Management of Soils V-26
    f. Engineering Uses of the Soils V-30
    g. Soil Infiltration V-36
    h. Soil Radioactivity V-37
    i. Relationship Between Soils and Vegetation V-40
  4. Conclusions V-41
  5. Work Scheduled V-42
B. Geology V-43
  1. Objectives V-43
  2. Methodology V-43
  3. Summary of Results V-44
    a. Physiography V-44
    b. Geologic History V-56
    c. Stratigraphy V-59
    d. Structural Geology V-70
    e. Geologic Hazards V-79
    f. Mineral Resources V-80
  4. Conclusions V-89
  5. Work Scheduled V-91

GLOSSARY V-92

REFERENCES V-99

APPENDICES V-101

V-1 Utah State University Soils Laboratory Logan, Utah...Soil Analysis Report V-102
V-2 Infiltration, Curve, Number, and Sediment Yields V-114
V-3 Soil Radioactivity Tests V-118
V-4 Extractable Alumina in Spent Shale and X Holes V-120

TABLE OF CONTENTS (Cont.)

Volume 2 (Cont.) Page

VI. HISTORIC AND SCIENTIFIC RESOURCES

- A. Cultural Resources VI-1
  - 1. Objectives VI-1
  - 2. Methodology VI-2
  - 3. Summary of Results VI-2
  - 4. Conclusion VI-17
  - 5. Work Scheduled VI-17
- B. Paleontological Resources VI-17
  - 1. Objectives VI-17
  - 2. Methodology VI-20
  - 3. Summary of Results VI-20
  - 4. Conclusions VI-27
  - 5. Work Scheduled VI-32

REFERENCES VI-33
- Cultural Resources VI-33
- Paleontological Resources VI-36

VII. AESTHETICS VII-1

- A. Objectives VII-1
- B. Methodology VII-1
- C. Summary of Results VII-1
  - 1. Regional Area VII-1
  - 2. Tracts U-a and U-b VII-2
    - a. The Ridgetop-Basin Landscape Unit. . VII-2
    - b. The Canyon Landscape Unit VII-10
    - c. The White River Landscape Unit . . . VII-10
- D. Conclusions VII-11
- E. Work Scheduled VII-15

LIST OF FIGURES

Volume 2		Following Page
IV-1	Vegetation Map	IV-2
IV-2	Sagebrush/Greasewood Type of Southam Canyon	IV-2
IV-3	Juniper Vegetation Type at Higher Elevations	IV-2
IV-4	Shadscale Vegetation Type near Evacuation Creek	IV-2
IV-5	Riparian Vegetation Type along the White River.	IV-2
IV-6	Biological Resources Sampling Locations.	IV-7
IV-7	Root System of Spiney Horse Brush. . .	IV-40
IV-8	Root System of Big Sagebrush	IV-40
IV-9	Root System of Shadscale	IV-40
IV-10	Root System of Rabbitbrush	IV-40
IV-11	Root System of Greasewood.	IV-40
IV-12	Deer Mouse (Peromyscus maniculatus) Escaping from Sherman Live Trap. . . .	IV-57
IV-13	Apache Pocket Mouse (Perognathus apache) from Sagebrush-Greasewood Trapping Grid	IV-57
IV-14	Radio and Color Band Collaring of Tranquilized Deer by Utah DWR.	IV-90
IV-15	Banded Deer - Evacuation Creek	IV-90
IV-16	Deer Migration Routes and Wintering Areas, and Telemetry Sightings	IV-90
IV-17	Site Map-Lizard Plots and Snake Observations	IV-104
IV-18	Milk Snake (Lampropeltis triangulum taylori) Probably a Rare Resident of the Tracks	IV-107
IV-19	Topiyoung of Red-tailed Hawks (Buteo jamaicensis) Bottom: Young of Prairie Falcons (Falco mexicanus).	IV-118
IV-20	Canada Geese Population on the White River, 1975.	IV-121
IV-21	BLM Grazing Allotments	IV-124
IV-22	Sheep on the Tracts.	IV-127
IV-23	Longtail Weasel (Mustelafrenata) near Air Monitoring Station A-4	IV-127
IV-24	Treehopper (Stictocephala sp.) on a Cottonwood Leaf.	IV-135
IV-25	Leaf-cutting Bee (Meyachile parallela) Collecting Pollen and Nectar from Gum Plant near the White River	IV-135
IV-26	Deep Blue Digger Wasp (Chlorian cyaneum) on Salt Cedar.	IV-135

LIST OF FIGURES (Cont.)

Volume 2 (Cont.) — Following Page

IV-27 Darkling Ground Beetle (Glyptasida crennicollis) Under a Flat Stone near State Road 45. . . . . IV-135
IV-28 VTN Personnel Studying Collected Organisms at the Field Laboratory. . . IV-149
IV-29 VTN Aquatic Biologist Collecting Aquatic Invertebrates in the White River. IV-149
IV-30 Utah Division of Wildlife Resources Personnel Electro-Shocking Fish in the White River. IV-149
V-1 Soils Map. V-2
V-2 Locations of Soil Infiltration Tests . V-37
V-3 Water and Geologic Resources Monitoring Stations V-44
V-4 Hydrogeologic Information, Borehole Number P-1 . . . . V-47
V-5 Physiographic Map of the Uinta Basin Region V-47
V-6 Major Tectonic Features of the Uinta Basin Region V-51
V-7 Drainage Basin Shaded Relief Map . . . V-51
V-8 Slope Gradient Map V-51
V-9 Structural Geologic Map. V-56
V-10 Count Diagram of Points Representing Joint Orientations Tracts U-a and U-b. V-56
V-11 Geologic Map of Oil Shale Tracts U-a and U-b; Uintah County, Utah V-60
V-12 Regional Geologic Cross-Section -- Through Oil Shale Tracts V-60
V-13 Geologic Cross-Section Through Oil Shale Tract U-a. V-60
V-14 Geologic Cross-Section Through Oil Shale Tract U-b. V-60
V-15 Measured Stratigraphic Section of the Upper Portion of the Parachute Creek Member of the Green River Formation (Section 1-A), Hells Hole Canyon, Utah V-66
V-16 Structural Contour Map of the Mahogany Marker Bed, Tracts Ua-Ub V-66
V-17 Measured Stratigraphic Sections near the Contact Between the Green River and Uinta Formations (Section 1-B) . . V-70
V-18 Count Diagram of Points Representing Joint Plane Orientations, Sec. 7, 8, 17, 18, T10S, R24E V-73

LIST OF FIGURES (Cont.)

Volume 2 (Cont.) — Following Page

V-19 Count Diagram of Points Representing Joint Plane Orientations, Sec. 23, 24 and 26, T10S, R25E V-73
V-20 Count Diagram of Points Representing Joint Plane Orientations, Sec. 31, 32, and 33, T10S, R24E V-73
V-21 Earthquakes through 1970 and Seismic Risk Map for the Western U.S. V-80
V-22 Precise Releveling for Subsidence Investigation. V-80
V-23 Precise Releveling Profile V-80
V-24 Mineral Resources of the Uinta Basin . . V-80
VI-1 Map of Uinta Basin, before 1900. . . . . VI-4
VI-2 Map of Uinta Basin, 1930's VI-4
VI-3 Ignacio Stage Stop VI-8
VI-4 McKean Projectile Points VI-13
VI-5 Small Projectile Points. VI-13
VI-6 Big Horn Sheep Petroglyph. VI-17
VI-7 Etched Stone Tablet. VI-17
VI-8 Plant Fossils. VI-27
VI-9 Insect Fossils VI-27
VI-10 Brontotheres VI-27
VII-1 Landscape Units and Photograph Orientations for Evaluating Aesthetic Resources. VII-2
VII-2 Southam Canyon VII-2
VII-3 Ridgetop Vegetation. VII-2
VII-4 Sunrise. VII-2
VII-5 Sunrise. VII-2
VII-6 Pinyon Tree. VII-2
VII-7 Waterpockets VII-2
VII-8 Geologic Detail. VII-2
VII-9 Geologic Detail. VII-2
VII-10 Balanced Rock. VII-2
VII-11 Balanced Rock. VII-2
VII-12 Rock Window. VII-2
VII-13 Duck Rock. VII-2
VII-14 Evacuation Creek VII-11
VII-15 Canyon Wall Cavities VII-11
VII-16 White River. VII-11
VII-17 White River Vegetation VII-11
VII-18 White River Panoramic. VII-11
VII-19 White River Panoramic. VII-11

LIST OF TABLES

Volume 2 Page

IV-1 Botanical Species List and Six-letter Computer Codes for Scientific Plant Names IV-9
IV-2 Fall 1974 Sagebrush/Greasewood Vegetation Type Characteristics IV-11
IV-3 Fall 1974 Juniper Vegetation Type Characteristics IV-12
IV-4 Fall 1974 Shadscale Vegetation Type Characteristics IV-13
IV-5 Fall 1974 Riparian Vegetation Type Characteristics IV-14
IV-6 Spring 1975 Sagebrush/Greasewood Vegetation Type Characteristics IV-16
IV-7 Spring 1975 Juniper Vegetation Type Characteristics IV-17
IV-8 Spring 1975 Shadscale Vegetation Type Characteristics IV-18
IV-9 Spring 1975 Riparian Vegetation Type Characteristics IV-19
IV-10 Fall 1975 Sagebrush/Greasewood Vegetation Type Characteristics IV-21
IV-11 Fall 1975 Juniper Vegetation Type Characteristics IV-22
IV-12 Fall 1975 Shadscale Vegetation Type Characteristics IV-23
IV-13 Fall 1975 Riparian Vegetation Type Characteristics IV-24
IV-14 Fall 1974 Production of Perennial Species in Each of the Four Vegetation Types . . . IV-30
IV-15 Production of Annual Grasses and Forbs in June 1975-in Each of Four Vegetation Types IV-33
IV-16 Fall 1975 Production by Species, Sagebrush/Greasewood Type IV-35
IV-17 Fall 1975 Production by Species, Juniper Type IV-36
IV-18 Fall 1975 Production by Species, Shadscale Type IV-37
IV-19 Fall 1975 Production by Species, Riparian Type IV-38
IV-20 Salinity Values for Some Soils near Evacuation Creek and the Associated Vegetation IV-46
IV-21 Scheduled Sampling Program of Kilometers of Flushing Transects Walked and Number of Trap Nights used for Terrestrial Vertebrates on 12 Sampling Sites from December, 1974 through October, 1975 . . . IV-50

LIST OF TABLES (Cont.)

Volume 2 (Cont.) Page

IV-22 Mammalian Species List from Observations on or within 1.6 km (1 mile) of Utah Oil Shale Tracts, December 1974 through October 1975 . . . . IV-52
IV-23 Mammal Densities as Determined by Flushing Transects on 12 Sites in Four Vegetation Types IV-53
IV-24 Rodent Densities as Determined by Livetrapping Grids in Four Vegetation Types During August, 1975 . . . . IV-57
IV-25 Numbers of Rodents Captured by Livetrapping Transects on 12 Sites in Four Vegetation Types IV-60
IV-26 Avian Species List from Observations on or within 1.6 km (1 mile) of Utah Oil Shale Tracts, December 1974 though October 1975 . . . . IV-64
IV-27 Bird Densities as Determined by Flushing Transects on 12 Sites in Four Vegetation Types IV-68
IV-28 Amphibian and Reptile Species List from Observations on or within 1.6 km (1 mile) of Utah Oil Shale Tracts, December 1974 through October 1975 . . . . IV-84
IV-29 Amphibians and Reptile Numbers Active Aboveground as Determined by Flushing Transects on 12 Sites in Four Vegetation Types IV-85
IV-30 December Deer Trend Count Oil Shale Tracts U-a and U-b IV-95
IV-31 Utah Oil Shale Tracts Deer Harvest Structure IV-97
IV-32 1975 Lizard Sampling Effort and Plot Size IV-103
IV-33 Total Number of Lizards Observed in Each Vegetation Plot and Species Diversity IV-106
IV-34 Numbers of Snakes Observed in Each Vegetation Type IV-107
IV-35 Correlation Coefficients Between Selected Lizard and Vegetation Parameters IV-110
IV-36 Correlation Coefficients Between Selected Snake and Vegetation Parameters. . IV-112
IV-37 Significant Correlation Coefficients Between Numbers of Snakes Observed and Numbers of Lizards Marked in Each Vegetation Type IV-114

LIST OF TABLES (Cont.)

Volume 2 (Cont.) Page

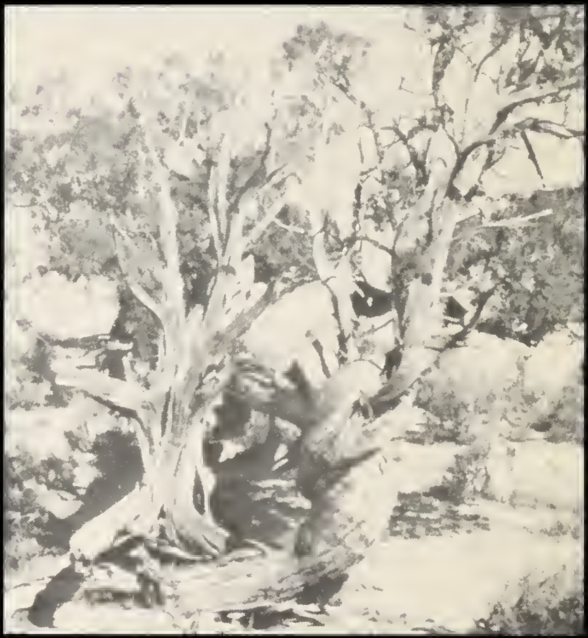
IV-38 Significant Correlation Coefficients Between Numbers of Snakes Observed and Numbers or Rodents Marked in Each Vegetation Type IV-115
IV-39 Raptor Reproductive Success IV-117
IV-40 Sheep Grazing Licenses on Utah Tracts U-a and U-b IV-124
IV-41 Insects of Oil Shale Tracts, Bonanza, Utah Diptera IV-132
IV-42 Chlorophyll Concentrations (mg/m^2). IV-151
IV-43 Quantitative Plankton Data IV-153
IV-44 Systematic List of Aquatic Invertebrates Collected from the White River (1974-75) with Reference to Food Habits of each Taxon IV-154
IV-45 Aquatic Invertebrate Data IV-161
IV-46 Fishes Collected from the White River (1975) IV-166
IV-47 Fishes Collected from the White River (1974) IV-167
IV-48 Average Microbial Numbers for Individual Sites IV-172
IV-49 Averages of Values of Microbial Activity Measurements for Individual Sites IV-176
IV-50 Nitrification Potential IV-181
IV-51 ATP Concentration Averages IV-182
V-1 Soil Classification V-23
V-2 Laboratory Analysis of Selected Soils . . . V-25
V-3 Results of X-ray Analysis of 15 Soil Samples from Oil Shale Tracts U-a and U-b . V-27
V-4 Results of the Boron Tests on Soil Samples from Oil Shale Tracts U-a and U-b . V-28
V-5 Estimated Herbage Yields in kg/ha and Land Use Capability Classes of Soils . . . V-29
V-6 Estimated and Measured Soil Properties Significant to Engineering Requirements . . V-31
V-7 Interpretations of Engineering Properties of Soils V-34
V-8 Summary of Soil Infiltration Rates V-39
V-9 Data Collected from the P, X, and G Holes V-46
V-10 Intervals of Cores on which Assay and Rock Mechanics Tests were Performed V-77
V-11 Approximate Depths of the Roof and Floor of the Mining Zone within the Bore Holes. . V-86
V-12 Nahcolite Content in Selected Core Intervals V-90

LIST OF TABLES (Cont.)

Volume 2 (Cont.) Page

VI-1 Description of the Prehistoric Sites. . . . VI-12
VI-2 Fossil Types Located During the Paleontological Investigation VI-23
VI-3 Description of the Paleontological Sites. . VI-24

IV
BIOLOGICAL RESOURCES



IV. BIOLOGICAL RESOURCES

A. VEGETATION

Vegetation studies began in June 1974 with a literature review and site reconnaissance. Field studies of vegetation on the tracts began in late summer 1974. In reviewing previous work and published information, one of the earliest notes pertaining to the vegetation of the Uinta Basin was found in the diary of Major Wesly Powell (1879), who traveled the White River from its confluence with the Green River. He noted that the streamside vegetation was abundant but that the sidehills and cliffs were dry and sometimes barren. The botanical study by Graham (1937) included descriptions of many important species in the oil shale region and the various plant communities of the Uinta Basin. The condition of the rangelands in the region following years of intensive grazing was the subject of an investigation by Stoddart and others (1938). Dastrup (1963) attempted to document some of the vegetational changes that have occurred in the grazing areas of the Uinta Basin since settlement. Interest in the natural history of Dinosaur National Monument apparently led to the development of two botanical studies that are relevant to the tracts in plant species and ecology. The ecological survey by Welsh (1957) was followed by a description of the flora by Holmgren (1962). Although Mountain Plants of Northeastern Utah, by Anderson and Holmgren (1969), provides line drawings and plant descriptions, the Manual of the Plants of Colorado, by Harrington (1964), is probably the best source of information for identifying plant species collected on the tracts.

The general objectives of the vegetation baseline study are as follows:

(a) compile data to determine conditions prior to development
(b) obtain data that will provide a record of change
(c) collect data relating to the distribution, density, and condition of the flora
(d) interpret ecological interrelationships, i.e., plant/animal
(e) conduct a productivity assessment of all vegetation types of the leased lands
(f) conduct briefings about the environment
(g) use collection procedures that are sufficiently complete and accurate so that statistical comparisons can be made with future data

(h) provide information about existing and potential vegetation to formulate an environmental protection and rehabilitation plan
(i) provide data about reproductive rates of existing vegetation

1. VEGETATION MAPPING

A map identifying the major vegetation types and their general distribution on the tracts was prepared. The map was compiled from a mosaic of aerial photographs, discussions with Bureau of Land Management (BLM) personnel responsible for grazing management of the tracts and adjacent areas, published information about the region, and extensive ground reconnaissance.

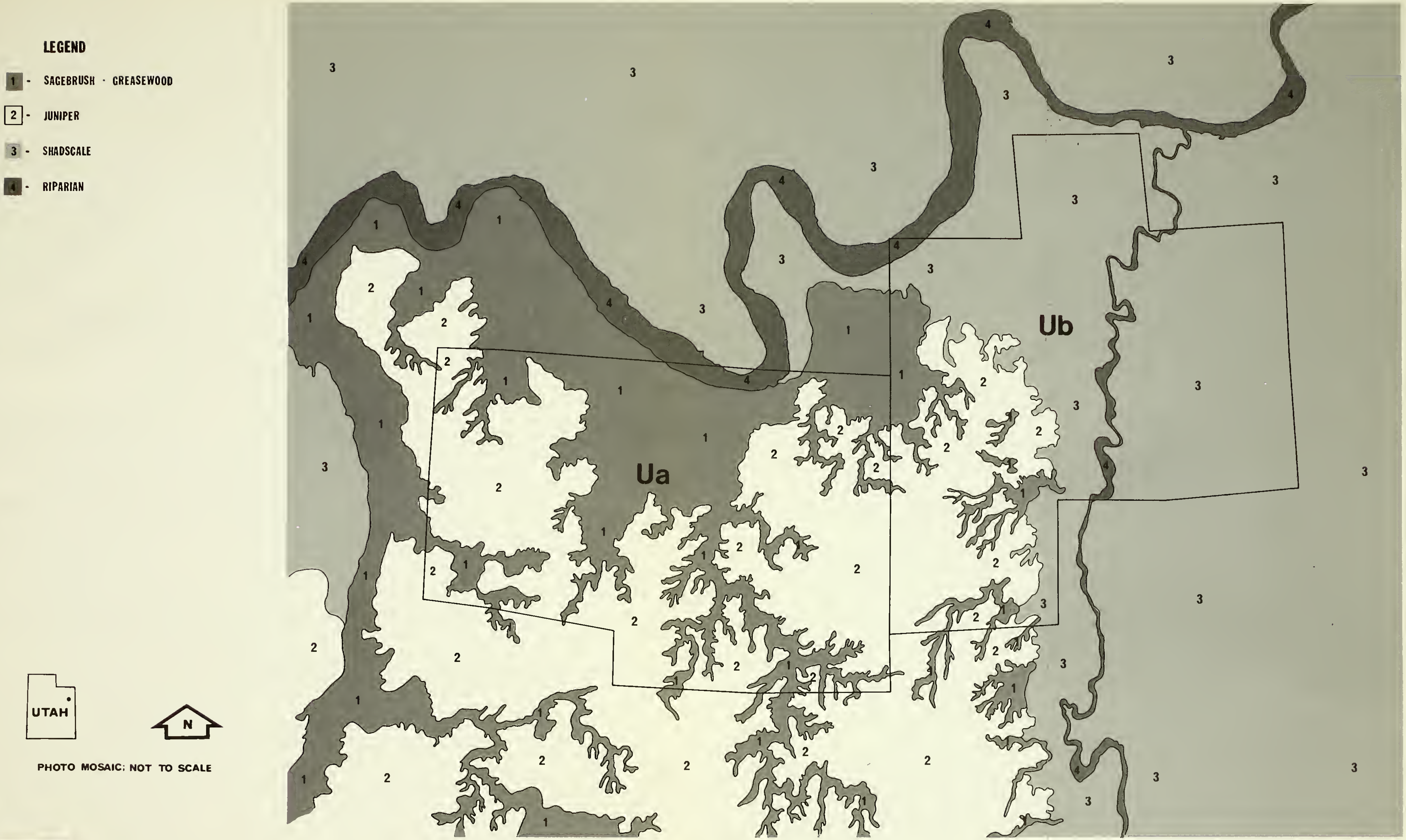
Four main vegetation types were identified and delineated (Figure IV-1). The types identified were sagebrush/greasewood (Figure IV-2), juniper (Figure IV-3), shadscale (Figure IV-4), and riparian (Figure IV-5). A more detailed breakdown into subtypes is possible, but it would not serve a specific purpose and would have complicated zoological inventory and monitoring. The delineation of types generally follows the nomenclature and descriptions by Stoddart et al. (1938), and more recently, by Harper and his students (1974).

The sagebrush/greasewood type generally covers drainages and uplands south of the White River but not at the higher elevations or to the east. The juniper type is found at the higher elevations, particularly on Tract U-a. Very limited numbers of pinyon pine are found in the juniper type, apparently because the juniper is at the lower margin of its elevational distribution and the sites are too harsh for pinyon. Much of the upland area to the east, on Tract U-b, is covered with the shadscale vegetation type, generally on dry slopes with shallow soils. The riparian type, as the name implies, is found in areas adjacent to water and moist soil. The principal areas of riparian vegetation are the White River bottomland and flood plain and the Evacuation Creek bottomland.

2. COMMUNITY STRUCTURE AND COMPOSITION

a. Objectives

The vegetation sampling program is being conducted to determine pre-development conditions, to collect data relative



VEGETATION MAP

FIGURE IV-1

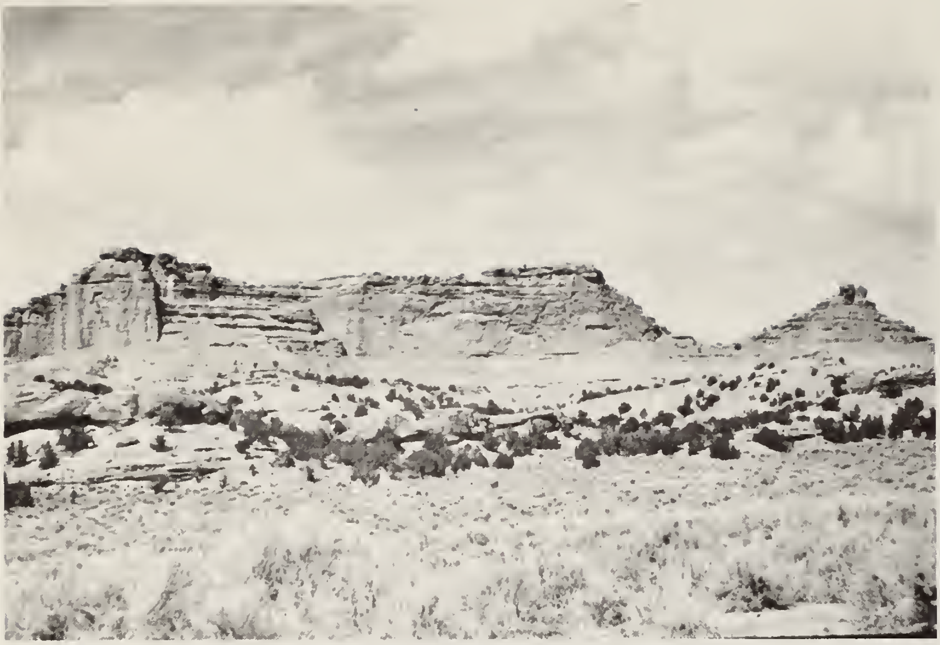


FIGURE IV-2 SAGEBRUSH/GREASEWOOD TYPE OF SOUTHAM CANYON.

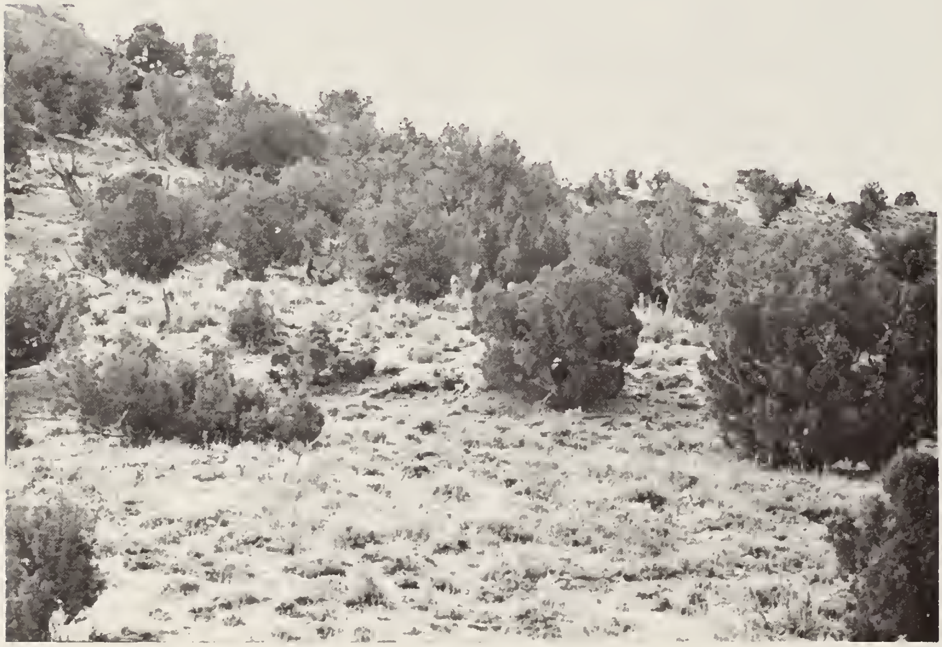


FIGURE IV-3 JUNIPER VEGETATION TYPE AT HIGHER ELEVATIONS.

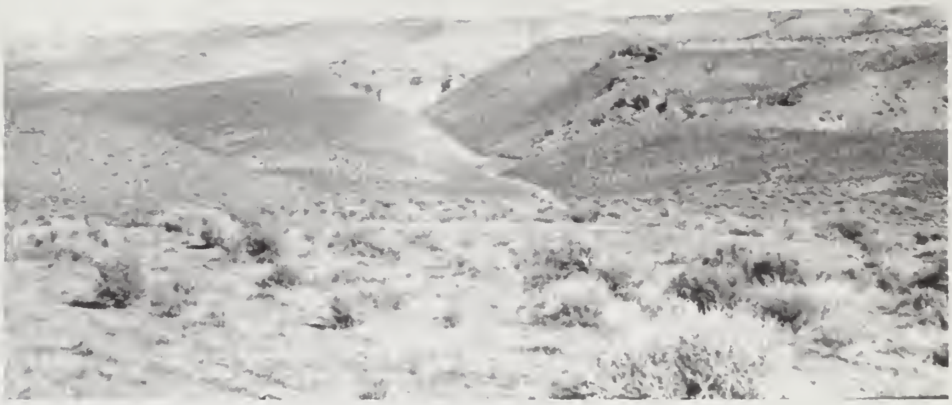


FIGURE IV-4 SHADSCALE VEGETATION TYPE NEAR EVACUATION CREEK.

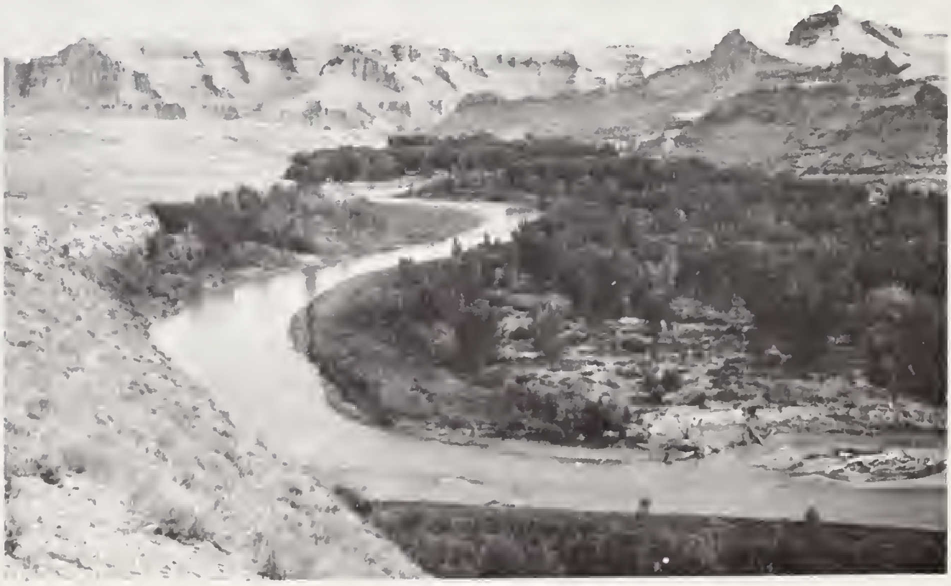


FIGURE IV-5 RIPARIAN VEGETATION TYPE ALONG THE WHITE RIVER

to plant distribution, density, and condition (composition). These data will provide information pertaining to existing and potential vegetation and will be sufficiently complete and accurate for statistical comparison with future data.

b. Methodology

The sampling procedures used are based on those of the IBP Desert Biome Program at Curlew Valley in northwestern Utah. The vegetation on the validation site at Curlew Valley is a salt-desert shrub type similar to that of the tracts, although much more uniform.

Within each of the four vegetation types five separate study sites were established to measure characteristics of plants in each type. Four plant attributes (species, height, cover, and density) were determined by two-person sampling teams. Twenty 4-m^2 (43-ft^2) plots were located randomly in each site (Figure IV-6). Data were recorded on field sheets in a manner that permitted easy transferral to computer cards.

The Desert Biome Program recommends that between 10 and 20 plots per site be used to approach sampling adequacy. Twenty plots per site was used on the tracts, with the option of adding additional plots after an estimate of the variability was obtained.

Within the two-year baseline study, vegetation is to be sampled each spring to estimate the characteristics of species maturing in June (mostly annual species) and the characteristics of associated shrubs and other perennials. Vegetation is also to be sampled each fall to estimate the parameters of late-summer maturing species (mostly perennials). The data reported are from 400 plots (four vegetation types x five sites x 20 plots).

In the first year of the baseline study there were three sampling periods--fall 1974, spring 1975, and fall 1975. A fourth sampling will be done in spring 1976. At the end of the fourth sampling period, data from each period will be pooled to provide an overall estimate of vegetation parameters within appropriate levels of statistical adequacy.

Field plot data were analyzed statistically to determine the means; a 90 percent confidence interval (C.I.) about the means; and the necessary sample size (number of plots) required to estimate within 25 percent of the true mean with a 90 percent statistical probability for each attribute measured for each species.

c. Summary of Results

The fall 1974 data apply only to the plots where the species were actually observed. The data were then converted to estimate cover, density, and dry matter on the basis of 4-m^2 plots averaged over 100 plots for each species in each vegetation type.

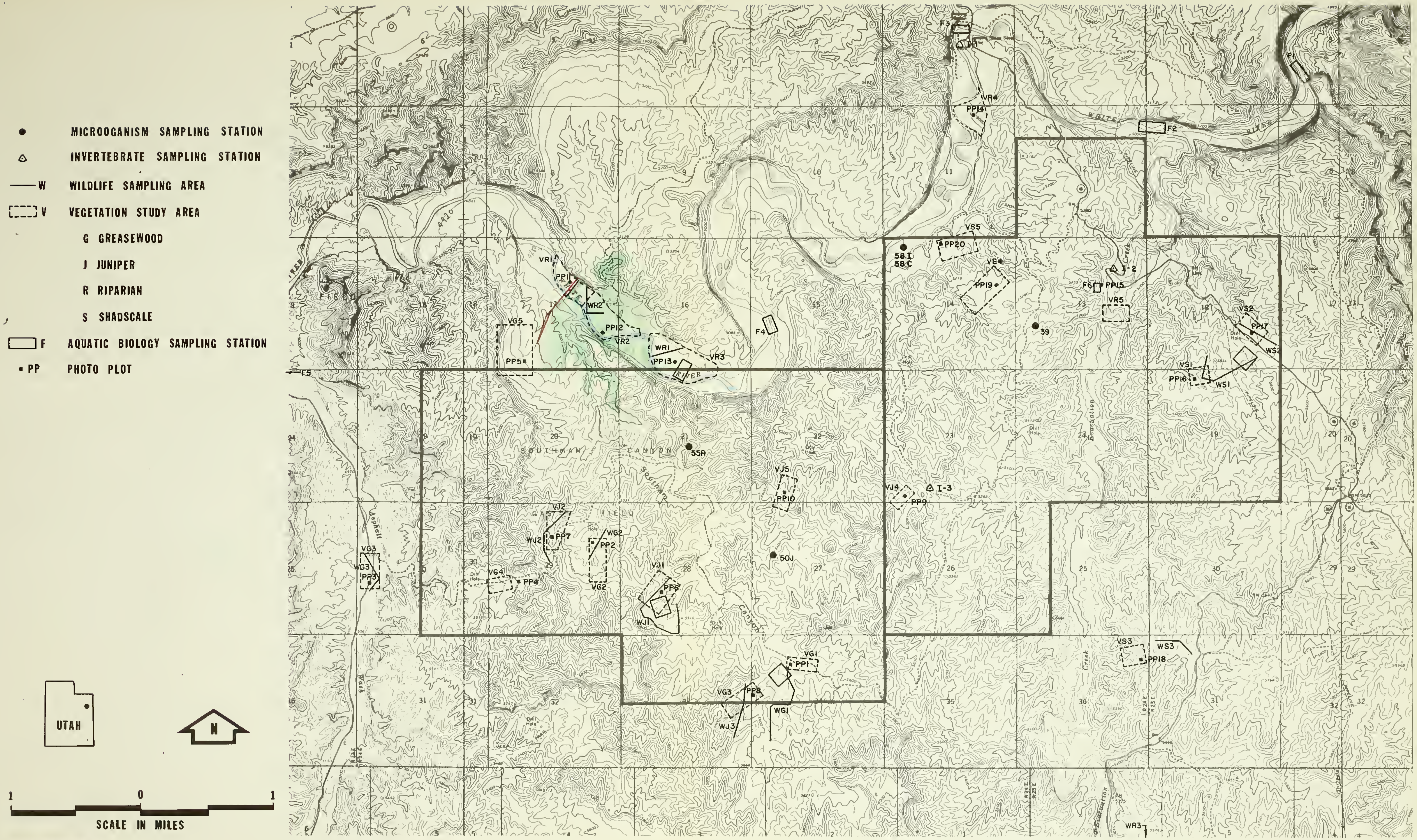
The species encountered in the September 1974 inventory do not represent the total species composition because some species did not occur in the plots and some species were not evident during the sampling period. For a complete species list, random botanical collecting was used to supplement the plot sampling (Table IV-1). Additional species wil undoubtedly be added to the list during the second year of the baseline study.

Vegetation Parameters, Fall 1974

Data from the fall 1974 sampling period are summarized in Tables IV-2, IV-3, IV-4, and IV-5. Scientific names have been abbreviated to a code for the first three letters of the generic name and the first three of the species name. In cases where an identification was not possible because of the absence of key anatomical features (such as seeds, etc.), a six-letter code for the genus or family name was used.

There is no tree canopy cover in the sagebrush/greasewood type. In September 1974 only about 16 percent of the ground surface was covered and 10 percent of this cover was litter. Russian thistle (*Salsola kali*), greasewood (*Sarcobatus vermiculatus*), and big sagebrush (*Artemisia tridentata*) each provided about 1 percent of the ground cover, and less dominant species covered the rest. In September 1974 this vegetation type had an average of 39 Russian thistle plants and 6 shadscale (*Atriplex confertifolia*) shrubs in each 4-m^2 plot. Big sagebrush, black sagebrush (*Artemisia nova*), and Indian ricegrass (*Oryzopsis hymenoides*) occurred about once in each plot, and about five *Stipa comata* plants occurred in each 4-m^2 plot.

Juniper (*Juniperus osteosperma*) is obviously the dominant species in height and general appearance in the juniper vegetation type. Twelve percent of the ground was covered by litter, 1 percent by black sagebrush, and juniper provided an overstory of about 12 percent cover. About 85 percent of the surface was bare ground. Litter and juniper canopy



BIOLOGICAL RESOURCE SAMPLING LOCATIONS

FIGURE IV-6

TABLE IV-1

BOTANICAL SPECIES LIST AND SIX-LETTER COMPUTER CODES FOR SCIENTIFIC PLANT NAMES

Six Letter Plant Code	Scientific Name
ABRELL	*Abronia elliptica*
ABRFRA	*Abronia fragrans*
ACHMIL	*Achillea millefolium*
AGRINE	*Agropyron inerme*
AGRREP	*Agropyron repens*
AGRSMI	*Agropyron smithii*
ALLIUM	*Allium* spp.
ALYOES	*Allyssum desertorum*
AMBPSI	*Ambrosia psilostachya*
AMEUTA	*Amelanchier utahensis*
AREKIN	*Arenaria kingii*
ARTEMI	*Artemisia* spp.
ARTFRI	*Artemisia frigida*
ARTLUO	*Artemisia ludoviciana*
ARTNOV	*Artemisia nova*
ARTSPI	*Artemisia spinescens*
ARTTRI	*Artemisia tridentata*
ASCCRY	*Asclepias cryptoceras*
ASTCAN	*Astragalus canadensis*
ASTCON	*Astragalus convallarius*
ASTRAG	*Astragalus* spp.
ASTCYM	*Astragalus cymboides*
ASTMOLL	*Astragalus mollissimus*
ASTSIM	*Astragalus simplifolcius*
ATRCAN	*Atriplex canescens*
ATRCON	*Atriplex confertifolia*
ATRCUN	*Atriplex cuneata*
ATRIPL	*Atriplex*
ATRPAT	*Atriplex patula*
ATRPOW	*Atriplex powellii*
BAIMUL	*Baileya multiradiata*
BARGRO	BARE GROUND
BASHYS	*Bassia hyssopifolia*
BORAGI (BORAGE)	Boraginaceae
BROTEC	*Bromus tectorum*
CARYOP	Caryophyllaceae
CASCHR	*Castillija chromosa*
CERLAN	*Ceratoides lanata*
CIRSIU	*Cirsium* spp.
CHEALB	*Chenopodium album*
CHOTEN	*Chorispora tenella*
CHRVIL	*Chrysopsis villosa*
CHRGRE	*Chrysothamnus greeni*
CHRNAU	*Chrysothamnus nauseosus*
CHRVIS	*Chrysothamnus viscidiflorus*
CLELUT	*Cleome lutea*
CLESER	*Cleome serrulata*
COMPAL	*Comandra pallida*
CRUCIF	Cruciferae
CRYAFF	*Cryptantha affinis*
CRYFLA	*Cryptantha flavoculata*
CRYGRA	*Cryptantha gracilis*
CRYLON	*Cryptantha longiflora*
CRYSER	*Cryptantha sericea*
CYMOPT	*Cymopteris* spp.
CYMACA	*Cymopterus acaulis*
CYMFEN	*Cymopterus fendleri*
OELBAR	*Delphinium barbeyi*
DELPHI	*Delphinium* spp.
OESPIN	*Descurainia pinnata*
OESSOP	*Descurania sophia*
OISSPI	*Distichlis spicata*
OISSTR	*Distichlis stricta*
EPHVIR	*Ephedra virdis*
EMLOFF	
EQUARV	*Equisetum arvense*
ERIGER	*Erigeron* spp.
ERIENG	*Erigeron engelmannii*
ERIURS	*Erigeron ursinus*
ERIOGO	*Eriogonum* spp.
ERIBAT	*Eriogonum batemanii*
ERIEFF	*Eriogonum effusum*
ERIMIC	*Eriogonum microthecum*
ERIOVA	*Eriogonum ovalifolium*
EUPHOR	*Euphorbia* spp.
EUPFEN	*Euphorbia fendelri*
EUPROB	*Euphorbia robusta*
EURLAN	*Eurotia lanata*
FESCUE (FESTUC)	*Festuca* spp.
FESOCT	*Festuca octoflora*
FORMEI	*Forsellesia meionandra*
GALCOL	*Galium coloradense*
GILCON	*Gilia congesta*
GILLEP	*Gilia leptomeria*
GILSIN	*Gilia sinuata*
GILSTE	*Gilia stenothyrsa*
GILPOL	*Gilia polycladon*
GRASPI	*Grayia spinosa*
GRISQU	*Grindelia squarosa*
GUTSAR	*Gutierrezia sarothrae*
HALGLO	*Halogeton glomeratus*
HEDBOR	*Hedysarum boreale*
HILJAM	*Hilaria jamesii*
HOLMIC	*Holodiscus microphyllus*
HORJUB	*Hordeum jubatum*

TABLE IV-1 (CON'T)

Six Letter Plant Codes	Scientific Name	Six Letter Plant Code	Scientific Name
HYMACA	*Hymenoxys acaulis*	POASAN	*Poa sandbergii*
HYMENO	*Hymenoxys* spp.	POLTRA	*Polanisia trachysperma*
HYMSCA	*Hymenoxys scaposa*	POPANG	*Populus angustifolia*
IVAAXI	*Iva axillaris*	POPFRE	*Populus fremontii*
JUNBAL	*Juncus balticus*	RANTES	*Ranunculus testiculatus*
JUNOST	*Juniperus osteosperma*	RHUTRI	*Rhus trilobata*
KOCAME	*Kochia Americana*	ROSWOO	*Rosa woodsii*
KOCHIA	*Kochia* spp.	SALEXI	*Salix exigua*
KOCSCO	*Kochia scoparia*	SALKAL	*Salsola kali*
KOCVES	*Kochia vestita*	SARVER	*Sarcobatus vermiculatus*
LAPRED	*Lappula redowskii*	SCIAME	*Scirpus americanus*
LEPIDI	*Lepidium* spp.	SCIPAL	*Scirpus paludosus*
LEPMON	*Lepidium montanum*	SENECI	*Senecio* spp.
LEPPER	*Lepidium perfoliatum*	SISALT	*Sisymbrium altissiumum*
LEPPUN	*Leptodoctylon pungens*	SISLIN	*Sisymbrium linifolium*
LEPREO (LAPREO)	*Lappula redowskii*	SITHYS	*Sitanion hystrix*
LEPWAT	*Leptodactylon watsonii*	SPAGRA	*Spartina gracilis*
LITRUD	*Lithospermum ruderale*	SPHAER (SPIRAL)	*Sphaeralcia* spp.
LITTER	Litter	SPHCOC	*Sphaeralcea coccinea*
LOLPER	*Lolium perenne*	SPHMUN	*Sphaeralcea munroana*
MALAFR	*Malcomia africana*	SPHPAR	*Sphaeralcea parvifolia*
MALSON	*Malcothrix sanchoides*	SPOAIR	*Sporobolus airoides*
MELOFF	*Melilotis officinalis*	SPOCRY	*Sporobolus cryptandrus*
MENALB (MENALS)	*Mentzelia albicaulis*	STALIT (SSTALI)	Standing dead annuals
MENHUM	*Mentzelia humilis*	STICOM (STYCOM)	*Stipa comata*
MULASP	*Muhlenbergia asperifolia*	STRCOR	*Streptanthus cordatus*
OENCAE	*Oenothera caespitosa*	SUADIA (SUAEOA)	*Suaeda*
OENDEN	*Oenothera deltoides*	SUAFRU	*Suaeda fruticosa*
OENMIN	*Oenothera minor*	SUANIG	*Suaeda nigra*
OGNSCA	*Oenothera scapoidea*	SUASUF	*Suaeda suffrutescons*
OPUNTI	*Opuntia* spp.	SUATOR	*Suaeda torreyana*
OPUPOL	*Opuntia polycantha*	TAMPEN	*Tamarix pentandra*
OROGAS	*Orobanche fasciculata*	TAROFF	*Taraxacum officinale*
OROLUD	*Orobanche ludoviciana*	TETNUT	*Tetradymia nuttallii*
ORYHYM	*Oryzopsis hymenoides*	TETSPI	*Tetradymia spinosa*
OXYLIN	*Oxybaphus linearis*	TOWINC	*Townsendia incana*
PENFRE	*Penstemon fremontii*	TRADUB	*Tragopogon dubius*
PETPUM	*Petradoria pumila*	UMBELL	*Umbelliferae*
PHACEL	*Phacelia* spp.	VULOCT	*Vulpia octoflora*
PHACOR	*Phacelia corrugata*		
PHLHOO	*Phlox hoodii*		
PHLLON	*Phlox longifolia*		
PHRCOM	*Phragmites communis*		
PHYALT	*Physocarpus alternans*		
PHYMON	*Physocarpus monogrnom*		
PINEDU	*Pinus edulis*		
PLAPAT	*Plantago patagonica*		
POAPRA (POAPRE)	*Poa pratensis*		

TABLE IV-2

FALL 1974 SAGEBRUSH/GREASEWOOD VEGETATION TYPE CHARACTERISTICS

Species	Height (cm)				Cover (cm^2/4m^2)				Density (individual/4m^2)			
	NUM OBS	MEAN	90% C.I.	Sample Size	NUM OBS	MEAN	90% C.I.	Sample Size	NUM OBS	MEAN	90% C.I.	Sample Size
AMBPSI	2	26.0	8.4 43.5	4.6	2	30.0	30.0 30.0	0.0	2	2.0	-0.9 4.9	21.6
ARTNOV	30	28.2	24.5 31.9	7.9	30	684.2	443.4 925.0	55.9	30	3.5	2.5 4.5	36.4
ARTTRI	34	33.2	29.9 36.6	5.6	34	1088.1	876.8 1299.4	20.5	34	4.2	3.6 4.9	13.6
ASTRAG	1	4.0	4.0 4.0	-	1	15.0	15.0 15.0	-	1	3.0	3.0 3.0	-
ATRCON	26	22.1	18.7 25.5	9.1	26	213.9	145.0 282.9	40.2	26	2.4	1.6 3.2	44.9
BARGRO	0	-	- -	-	100	33718.5	32519.5 35147.2	2.0	0	-	- -	-
CHRVIS	21	32.9	29.6 36.2	3.1	22	561.6	368.1 755.1	38.3	21	2.0	1.5 2.5	20.6
CRUCIF	12	28.3	21.6 34.9	9.0	12	12.2	5.3 19.0	52.1	12	1.5	0.9 2.1	26.2
CRYGRM	0	-	- -	-	16	833.1	-263.9 1903.1	374.7	0	-	- -	-
ERIGER	2	6.5	-6.6 19.6	41.5	2	62.0	-107.4 231.4	75.8	2	2.0	-0.9 4.9	21.6
ERIOGO	7	17.0	10.3 23.7	13.1	7	17.9	4.4 31.4	48.3	7	1.7	0.6 2.8	33.0
EURLAN	6	24.0	13.7 34.3	12.8	6	95.0	16.2 173.8	47.3	6	1.0	1.0 1.0	0.0
GRASPI	19	38.1	33.0 43.1	4.8	19	1073.9	627.2 1520.7	47.6	18	1.4	1.1 1.8	12.7
GUTSAR	24	23.0	20.3 25.8	4.9	24	117.8	48.7 186.9	122.0	24	3.5	1.6 5.4	106.3
HILJAM	11	10.0	8.4 11.6	3.6	11	105.0	27.2 182.8	81.1	11	4.6	2.9 6.4	20.6
KOCVES	5	39.4	27.0 51.8	5.3	5	198.0	0.8 395.2	52.9	4	4.3	- 8.5	37.3
LITTER	0	-	- -	-	99	4247.0	3038.3 5455.7	128.3	0	-	- -	-
OPUNTI	6	5.2	4.0 6.3	3.5	7	46.0	15.0 77.0	38.3	6	1.0	1.0 1.0	-
ORYHYM	44	24.9	22.7 27.1	5.4	44	188.5	120.9 256.2	90.6	44	2.7	2.2 3.3	28.2
SALKAL	33	15.8	12.9 18.8	18.6	34	1360.9	907.7 1814.1	60.3	34	114.8	81.0 148.6	47.1
SARVER	31	54.2	46.2 62.2	10.8	37	1366.7	739.3 1994.1	124.8	30	2.4	1.8 3.0	32.4
SITHYS	1	15.0	15.0 15.0	-	1	16.0	16.0 16.0	-	1	1.0	1.0 1.0	-
SPHAER	5	13.6	10.9 16.3	2.1	5	21.0	5.3 36.7	29.9	5	1.4	0.6 2.2	17.7
SPOCRY	1	25.0	25.0 25.0	-	1	155.0	155.0 155.0	-	1	4.0	4.0 4.0	-
STICOM	47	17.6	16.0 19.1	5.6 5.6	47 47	167.9	127.1 208.6	44.3	47	11.5	9.4 13.6	24.8
TETSPI	7	35.9	29.3 42.4	2.8	7	354.3	64.7 643.8	56.4	7	1.3	0.9 1.6	6.2

Data are for the number of observations, mean, 90% confidence interval about the mean and sample size required to estimate within 25% of the mean with a 90% statistical confidence.

FALL 1974 JUNIPER VEGETATION TYPE CHARACTERISTICS

Species	Height (cm)				Cover ($cm^2/4m^2$)				Density (individual/$4m^2$)			
	NUM OBS	MEAN	90% C.I.	Sample Size	NUM OBS	MEAN	90% C.I.	Sample Size	NUM OBS	MEAN	90% C.I.	Sample Size
AGRSMI	3	30.0	6.1 53.9	14.9	3	78.0	-66.6 222.6	80.6	3	6.6	-5.5 18.8	78.2
ARTLUD	28	6.1	5.1 7.0	9.8	28	98.4	54.2 142.2	83.4	26	1.7	1.4 2.1	13.4
ARTNOV	56	11.5	9.6 13.4	24.8	60	763.8	581.4 946.2	54.7	55	3.8	3.1 4.6	32.8
ARTTRI	5	12.8	6.4 19.1	13.0	5	764.2	-427.2 1955.6	129.6	5	3.0	-0.1 6.1	55.3
ASTRAG	20	16.3	13.1 19.5	11.2	20	128.4	75.1 181.6	50.1	20	1.9	1.5 2.2	11.0
[illegible]	[illegible]	12.2	10.0 14.5	14.2	29	225.5	[illegible] 322.0	79.7	29	2.3	1.7 3.0	32.2
BARGRO	0	-	- -	-	100	34278.2	32796.1 25760.3	3.0	0	-	- -	-
BOUGRA	1	6.0	6.0 6.0	-	1	130.0	130.0 130.0	-	1	4.0	4.0 4.0	-
CHRGRE	5	10.4	5.4 15.4	12.5	5	50.8	-25.7 127.3	120.8	5	2.2	0.7 3.7	24.1
CHRVIS	29	13.2	10.2 16.3	22.7	29	382.9	271.1 494.8	37.1	29	5.9	4.3 7.4	30.8
CHRGRE	2	14.5	-19.1 48.1	54.5	2	355.0	-623.2 1333.2	77.1	2	2.0	2.0 2.0	-
COMPAL	3	9.3	6.4	2.2	3	21.0	-4.2 46.2	33.7	3	1.3	0.5 2.1	8.1
CRUCIF	21	26.6	20.5 32.8	16.4	21	26.6	16.4 36.9	45.4	21	3.9	-0.1 7.9	319.1
CRYGRM	0	-	- -	-	4	1258.8	-269.2 2786.7	56.1	0	-	- -	-
DISSTR	11	11.1	9.8 12.4	2.1	11	321.0	-37.4 679.4	184.0	11	21.5	5.2 37.9	84.8
EPHVIR	4	18.3	7.3 29.2	13.8	4	315.0	-108.3 738.3	68.8	4	1.3	0.7 1.8	6.9
ERIGER	40	7.2	5.7 8.7	26.3	40	69.1	50.1 88.1	48.4	40	5.1	2.5 7.7	161.9
ERIOGO	24	8.5	6.8 10.3	14.8	24	35.6	11.8 59.4	157.9	24	2.8	1.5 4.0	72.8
EUPHUR	48	3.5	3.0 4.0	13.1	48	31.4	22.5 40.3	61.2	48	2.6	2.0 3.3	40.9
GUTSAR	55	13.9	12.5	8.0	55	126.7	64.2 189.3	214.4	55	3.7	1.7 5.8	259.1
HALGLO	1	12.0	12.0 12.0	-	1	100.0	100.0 100.0	-	1	20.0	20.0 20.0	-
HILJAM	33	10.5	9.4 11.6	5.7	33	302.7	169.1 436.3	102.8	33	27.9	15.3 40.4	107.4
HYMENO	4	6.8	1.4 12.1	23.7	4	48.8	-10.0 107.5	55.4	4	1.0	1.0 1.0	-
JUNOST	21	158.3	112.5 204.1	25.7	47	9860.4	7202.3 12518.5	54.6	19	1.2	0.9 1.4	8.5
LITTER	0	-	- -	-	100	4777.5	3201.1 6353.8	174.2	0	-	- -	-
MULASP	1	6.0	6.0 6.0	-	1	130.0	130.0 130.0	-	1	2.0	2.0 2.0	-
OPUNTI	2	5.5	1.1 9.9	6.4	2	65.0	-8.0 138.0	12.8	2	1.0	1.0 1.0	-
ORYHYM	54	19.7	17.0 21.5	7.6	54	107.6	46.9 168.3	274.5	54	3.2	2.5 4.0	46.8
PHLHOO	5	4.8	0.8 8.0	47.0	6	15.0	-3.3 33.3	103.0	6	1.0	1.0 1.0	-
POAFEN	1	37.0	37.0 37.0	-	1	2.0	2.0 2.0	-	1	1.0	1.0 1.0	-
POASAN	5	15.6	5.6 25.6	22.1	5	40.0	6.9 73.1	36.5	5	2.0	0.9 3.1	16.2
SALKAL	1	6.0	6.0 6.0	-	1	10.0	10.0 10.0	-	1	1.0	1.0 1.0	-
SENECO	2	16.5	12.1 20.9	0.7	2	275.0	202.0 348.0	0.7	2	6.5	5.0 8.0	0.5
SITHYS	3	24.0	14.5 33.5	3.7	3	33.3	25.5 41.2	1.3	3	2.0	0.6 3.4	10.8
SOLRIG	7	18.9	6.6 31.1	35.5	8	63.6	26.0 101.2	34.9	8	2.0	1.2 2.8	15.5
SPHAER	1	10.0	10.0 10.0	-	1	20.0	20.0 20.0	-	1	1.0	1.0 1.0	-
STICOM	1	18.0	18.0 18.0	-	1	40.0	40.0 40.0	-	1	3.0	3.0 3.0	-
TETSPI	1	30.0	30.0 30.0	-	1	150.0	150.0 150.0	-	1	1.0	1.0 1.0	-

Data are for the number of observations, mean, 90% confidence interval about the mean and sample size required to estimate within 25% of the mean with a 90% statistical confidence.

TABLE IV-4

FALL 1974 SHADSCALE VEGETATION TYPE CHARACTERISTICS

Species	Height (cm)				Cover (cm²/4m²)				Density (individual/4m²)			
	NUM OBS	MEAN	90% C.I.	Sample Size	NUM OBS	MEAN	90% C.I.	Sample Size	NUM OBS	MEAN	90% C.I.	Sample Size
AGRSMI	1	26.0	26.0 26.0	-	1	150.0	150.0 150.0	-	1	8.0	8.0 8.0	-
ARTLUD	1	17.0	17.0 17.0	-	1	110.0	110.0 110.0	-	1	1.0	1.0 1.0	-
ARTNOV	27	28.0	24.9 31.1	4.9	28	1559.8	1157.7 1961.9	27.8	27	4.3	3.2 5.4	26.5
ARTTRI	40	27.0	23.3 30.7	11.8	40	2928.8	2086.9 3770.7	52.9	40	3.6	3.0 4.3	20.2
ASTRAG	39	19.6	17.8 20.2	5.2	39	67.1	45.8 88.3	62.7	39	3.6	2.6 4.6	45.5
ATRCON	88	19.0	17.8 21.4	5.4	90	1261.3	1043.5 1479.1	42.9	88	4.9	4.1 5.6	33.5
BARGRO	0	-	- -	-	100	36115.9	35623.3 36608.5	0.3	0	-	- -	-
CHRVIS	8	31.6	23.9 39.4	6.0	9	542.8	226.2 859.3	39.4	8	1.5	1.0 2.0	11.0
CRUCIF	1	30.0	30.0 30.0	-	1	20.0	20.0 20.0	-	1	1.0	1.0 1.0	-
CRYGRM	0	-	- -	-	7	793.6	-35.4 1622.6	92.1	0	-	- -	-
ERIGER	13	10.9	8.7 13.1	7.3	13	158.6	42.0 275.3	97.1	13	4.2	0.9 7.6	112.9
ERIOGO	3	17.7	5.8 29.5	10.6	3	565.0	-429.2 1559.2	72.6	3	10.7	-0.4 21.7	25.2
EUPHUR	2	3.0	-2.8 8.8	38.5	2	26.5	22.1 30.9	0.3	2	1.0	1.0 1.0	-
EURLAN	4	12.0	8.9 15.1	2.6	4	72.5	18.6 126.4	21.1	4	1.8	0.7 2.8	13.0
GUTSAR	36	17.2	15.1 19.2	8.1	36	154.9	84.6 225.2	118.5	35	6.5	4.2 8.8	70.6
HALGLO	24	4.4	3.6 5.2	11.6	24	108.3	70.6 153.9	42.9	24	45.4	18.9 72.0	121.9
HILJAM	10	12.0	8.1 15.9	14.2	10	407.0	279.5 2534.5	84.7	9	40.3	15.7 65.0	43.2
KOCVES	3	28.0	19.5 36.5	2.2	3	436.7	-120.2 993.5	38.1	3	2.0	0.6 3.4	10.8
LITTER	0	-	- -	-	80	351.4	171.9 530.8	333.8	0	-	- -	-
OPUNTI	14	5.5	5.1 5.9	1.3	14	179.3	115.9 242.7	24.4	14	2.3	0.7 3.9	97.4
ORYHYM	18	21.6	18.2 24.9	6.3	18	122.1	64.4 179.9	57.9	18	2.8	1.9 3.8	30.6
SALKAL	10	5.2	3.9 6.5	8.1	10	595.4	2.7 1188.0	130.6	10	38.9	9.2 268.6	115.0
SARVER	7	41.3	27.2 55.4	9.9	9	531.8	334.2 2729.3	70.9	7	1.8	1.2 2.5	10.2
SITHYS	1	20.0	20.0 20.0	-	1	20.0	20.0 20.0	-	1	1.0	1.0 1.0	-
SPHAER	5	13.4	9.4 17.4	4.7	5	58.0	25.6 79.5	15.7	5	3.2	0.6 5.7	34.7
STICOM	1	13.0	13.0 13.0	-	1	50.0	50.0 50.0	-	1	1.0	1.0 1.0	-
TETSPI	14	25.6	20.5 30.8	8.0	15	748.1	271.2 1225.1	85.9	13	2.2	1.3 3.1	27.8

Data are for the number of observations, mean, 90% confidence interval about the mean and sample size required to estimate within 25% of the mean with a 90% statistical confidence.

TABLE IV-5

FALL 1974 RIPARIAN VEGETATION TYPE CHARACTERISTICS

Species	Height (cm)				Cover (cm^2/4m^2)				Density (individual/4m^2)			
	NUM OBS	MEAN	90% C.I.	Sample Size	NUM OBS	MEAN	90% C.I.	Sample Size	NUM OBS	MEAN	90% C.I.	Sample Size
AGRSMI	21	57.1	47.8 66.4	8.2	23	494.6	243.5 745.8	87.4	23	26.7	15.9	54.7
AMBPSI	5	19.4	12.9 25.9	5.9	5	130.0	35.7 224.3	28.0	5	9.0	2.5 15.5	
ARTLUD	1	85.0	85.0 85.0	-	1	5281.0	5281.0 5281.0	-	1	1.0	1.0 1.0	-
ARTTRI	9	71.7	55.8 87.5	5.7	9	2447.8	592.7 4302.8	66.6	9	1.8	1.0 2.6	23.2
ASTRAG	1	30.0	30.0 30.0	-	1	10.0	10.0 10.0	-	1	1.0	1.0 1.0	-
ATRPAT	1	86.0	86.0 86.0	-	1	770.0	770.0 770.0	-	1	1.0	1.0 1.0	-
BARGRO	0	-	- -	-	100	8854.2	6807.3 10901.1	85.5	0	-	- -	-
CENPAU	0	-	- -	-	1	40.0	40.0 40.0	-	1	216.0	216.0 216.0	-
CHRNAU	21	81.5	68.6 94.4	7.7	24	2076.7	531.3 3622.1	196.5	21	1.9	1.3 2.4	26.7
CHRVIS	44	83.7	74.9 92.5	7.8	45	2919.4	1551.1 4177.7	133.6	44	6.1	4.6 7.7	45.7
CIRSIU	0	-	- -	-	1	119.0	119.0 119.0	-	1	14.0	14.0 14.0	-
CLELIG	1	24.0	24.0 24.0	-	1	20.0	20.0 20.0	-	1	1.0	1.0 1.0	-
CRYGRM	0	-	- -	-	1	1250.0	1250.0 1250.0	-	0	-	- -	-
DISSTR	40	19.2	17.3 21.0	5.8	40	1558.2	657.0 2449.4	209.4	39	76.4	46.4 106.2	95.6
EQUARV	6	40.5	22.3 58.7	13.9	6	169.8	-10.6 350.2	77.6	6	271.3	-41.4 584.0	91.4
GUTSAR	3	45.0	22.4 67.6	5.9	3	8433.3	-314.4 17181.0	25.2	3	2.3	0.3 4.4	18.6
IVAAXI	11	19.5	14.6 24.3	9.2	11	103.2	31.3 175.1	71.6	11	9.3	4.0 14.6	48.0
JUNBAL	1	64.0	64.0 64.0	-	1	480.0	480.0 480.0	-	1	464.0	464.0 464.0	-
KOCSCO	4	50.0	5.4 94.6	30.3	4	1077.3	-332.7 2487.2	65.3	4	130.3	-21.2 281.7	51.5
LITTER	0	-	- -	-	0	24831.2	22314.3 27348.1	16.3	0	-	- -	-
MELOFF	2	28.0	-24.6 80.6	35.8	2	110.0	110.0 110.0	-	2	20.0	14.2 25.8	0.9
MULASP	1	45.0	45.0 45.0	0.0	1	15.0	15.0 15.0	0.0	1	2.0	2.0 2.0	0.0
OPUNTI	0	-	- -	-	1	50.0	50.0 50.0	-	0	-	- -	-
PHRCOM	1	84.0	84.0 84.0	-	1	210.0	210.0 210.0	-	1	1.0	1.0 1.0	-
POAFEN	4	45.8	23.7 67.8	8.8	4	129.5	-13.8 272.8	46.6	4	55.3	-11.9 122.9	56.4
POPFRE	11	2113.1	1055.7 3170.4	37.0	22	23362.7	17642.6 29082.8	19.4	11	2.9	1.1 4.7	56.7
RHUTRI	1	15.0	15.0 15.0	-	1	55.0	55.0 55.0	-	1	3.0	3.0 3.0	-
SALEXI	11	158.8	61.0 256.7	56.0	12	1229.3	360.3 2198.2	101.6	11	2.4	1.2 3.5	33.0
SALKAL	15	18.7	14.0 23.5	13.6	15	887.7	366.2 1409.0	72.9	15	54.9	4.3 105.5	179.8
SARVER	7	421.7	-91.6 935.3	125.0	10	6031.3	2805.2 9257.4	37.7	8	1.6	1.0 2.2	13.8
SISALT	2	63.5	-54.8 181.8	35.2	2	70.0	-105.2 245.2	63.6	2	2.5	1.0 4.0	3.5
SPHAER	2	0.0	-6.6 22.6	33.8	2	12.5	5.2 19.8	3.5	2	2.0	-0.9 4.9	21.6
SPOAIR	6	32.0	10.6 53.4	30.6	7	274.3	123.4 425.1	25.5	6	2.3	1.1 3.5	18.0
TAMPEN	13	300.8	119.4 542.2	84.6	18	10596.7	5332.6 15860.8	63.9	14	4.6	2.7 6.5	33.7

Data are for the number of observations, mean, 90% confidence interval about the mean and sample size required to estimate within 25% of the mean with a 90% statistical confidence.

overlap considerably as surface cover. *Hillaria jamesii* was the most frequently encountered species, averaging nine plants per plot. Several other species occurred one to four times in a plot, including black sagebrush, one of the major sources of plant cover.

In the saltbush type, 90 percent of the ground surface was bare in the fall of 1974 and 1 percent was covered by litter. Black sagebrush, big sagebrush, and shadscale covered 7 percent of the surface, and less dominant species covered the rest. There is no tree canopy cover in the saltbush type. An average of 11 halogeton (*Halogeton glomeratus*) plants and 14 Russian thistle plants were encountered in each plot. Several shrubs occurred on an average of one to four times in each 4-m^2 plot, including the shrubs that accounted for most of the live plant cover.

The riparian vegetation type had only 21 percent bare ground in September 1974 compared with the 84 percent to 90 percent bare ground encountered in the other vegetation types. Sixty-one percent of the surface was covered by litter. Five percent of the ground cover was saltcedar (*Tamarix pentandra*); 4 percent, rabbitbrush (*Chrysothamnus* spp.); and 1.5 percent, greasewood. The remaining surface was covered by a variety of less dominant plants. Cottonwood trees (*Populus fremontii*) provided a canopy over about 12.5 percent of the ground surface. Saltgrass (*Distichlis stricta*), equisetum (*Equisetum arvense*), and greasewood were encountered most frequently in the 4-m^2 plots.

Vegetation Parameters, Spring 1975

The four vegetation attributes measured in 1975 differed from those of 1974 because of more favorable weather conditions in 1974. Cover, height, and density measured during the 1975 spring assessment (June 9 to 13) indicated a large amount of open space (or bare ground) between the dominant shrubs and trees (Table IV-6, IV-7, IV-8, and IV-9). Sampling intensity was adequate for most plant heights because this characteristic is easily and directly measured and there is little need for sampling judgment.

The sampling of cover required practice and judgment, even though standard methods and metric-area frames were used. Cover was estimated for those species which were sampled in a statistically adequate manner (a 90 percent level of significance within 25 percent of the mean). The exceptions were species that occurred infrequently or whose cover attribute was variable and difficult to estimate. Some examples of the species sampled adequately were

TABLE IV-6

SPRING 1975 SAGEBRUSH-GREASEWOOD VEGETATION TYPE CHARACTERISTICS
MEAN, 90 PERCENT CONFIDENCE INTERVAL
AND ESTIMATED SAMPLE SIZE USING 4m² PLOTS

SPECIES	Height (cm)				Cover (cm²/4m²)				Density (Individual/4m²)			
	NUM OBS	MEAN	90% C.I.	SAMPLE SIZE	NUM OBS	MEAN	90% C.I	SAMPLE SIZE	NUM OBS	MEAN	90% C.I.	SAMPLE SIZE
ALLIUM	8	15.25	12.49 18.01	3.3	8	11.38	3.72 19.03	45.3	8	1.50	1.00 2.00	11.0
ARTNOV	77	17.38	15.28 19.47	17.9	82	214.27	179.55 248.99	34.4	1	2.00	2.00 2.00	0.0
ARTSPI	16	11.31	8.75 13.83	11.7	17	59.82	40.87 78.78	24.4	1	2.00	2.00 2.00	0.0
ARTTRI	175	25.25	24.69 27.81	9.9	195	485.57	425.67 545.48	47.5	5	1.80	0.63 2.97	22.7
ASTRAG	6	5.67	4.71 6.63	2.0	6	45.83	22.38 69.29	18.0	6	1.17	0.84 1.49	5.3
ATRCON	79	19.41	16.63 22.18	25.8	98	175.58	128.00 223.15	103.4	7	3.57	1.17 5.98	38.3
BARGRO	0	0.00	0.00 0.00	0.0	113	34951.16	34247.62	0.7	0	0.00	0.00 0.00	0.0
BORAGI	22	10.86	9.29 12.44	6.8	23	1806.09	255.68 3356.49	249.7	23	895.04	134.37 1655.72	244.8
BROTEC	87	20.22	18.93 21.50	5.6	88	1593.05	1061.65 2124.44	156.7	88	1443.73	970.14 1917.31	151.5
CHRNAU	4	37.50	27.29 47.71	2.8	4	837.50	243.38 1431.62	19.2	0	0.00	0.00 0.00	0.0
CHRVIS	28	25.36	22.59 28.12	5.0	32	236.25	185.37 286.13	22.8	0	0.00	0.00 0.00	0.0
CLELUT	13	25.00	22.54 27.46	1.7	13	141.54	81.35 201.72	32.4	13	16.46	10.58 22.34	22.9
CRUCIF	21	34.17	32.19 42.10	5.5	23	49.30	29.06 69.55	57.1	22	7.91	0.22 15.60	305.7
EUPHOR	5	1.60	0.79 2.41	13.5	5	15.00	9.48 20.52	7.2	5	1.60	0.79 2.41	13.5
EURLAN	6	24.83	18.70 30.97	4.2	8	147.50	69.71 225.29	27.8	0	0.00	0.00 0.00	0.0
FESCUE	5	10.80	6.85 14.75	7.1	5	48.00	17.84 78.16	21.0	5	85.20	-23.81 195.21	86.8
GRASPI	34	32.50	29.51 35.49	4.6	50	813.54	601.07 1026.01	54.6	0	0.00	0.00 0.00	0.0
GUTSAR	49	14.63	13.42 15.85	5.4	53	48.06	38.48 57.63	33.7	12	2.17	1.44 2.89	18.2
HILJAM	21	10.62	9.28 11.95	4.9	21	123.57	74.60 172.54	48.2	21	12.19	6.20 18.18	74.0
KOCAME	16	21.75	15.29 28.21	20.0	17	71.47	51.51 91.43	19.0	13	3.00	2.17 3.83	13.6
LEPMON	13	36.15	28.91 43.39	7.2	13	36.15	16.66 55.65	52.2	12	1.67	1.33 2.00	6.6
LEPREO	10	8.60	5.83 11.37	13.7	10	46.60	14.04 79.16	64.4	10	24.90	7.32 42.48	65.7
LITRUO	4	6.75	2.73 10.77	13.5	4	100.50	-11.98 212.98	47.7	4	55.50	-2.72 113.72	41.9
LITTER	0	0.00	0.00 0.00	0.0	112	1206.79	430.30 1983.27	741.9	0	0.00	0.00 0.00	0.0
MENALS	12	20.00	18.10 21.90	1.5	12	285.75	93.61 477.89	74.0	12	213.92	27.94 399.89	123.6
OPUNTI	4	8.00	6.26 9.74	1.8	4	218.75	-90.52 523.02	76.1	1	1.00	1.00 1.00	0.0
ORYHYM	45	30.82	29.25 32.39	1.9	46	295.11	188.87 401.35	95.4	41	4.80	2.70 6.91	125.2
SALKAL	16	6.75	5.61 7.89	6.5	16	55.63	39.36 71.89	19.4	16	22.00	15.33 28.67	20.9
SARVER	78	47.53	37.21 57.84	58.8	93	550.32	230.80 869.85	501.6	0	0.00	0.00 0.00	0.0
SISLIN	8	40.88	34.15 47.60	2.7	8	20.00	13.19 26.81	11.6	8	5.75	-0.83 12.33	131.2
SITHYS	23	23.48	20.93 26.03	4.0	24	174.90	-43.69 393.61	554.2	18	1.44	1.12 1.76	12.7
SPHCOC	16	20.69	15.59 25.78	13.0	16	85.94	27.56 144.32	104.8	16	1.06	0.95 1.17	2.4
SPIFAL	5	25.00	10.06 39.94	19.0	5	26.00	15.73 36.27	8.3	4	1.00	1.00 1.00	0.0
STICOM	43	39.07	36.30 41.84	3.5	43	566.63	418.47 714.79	47.0	43	14.02	11.23 16.61	27.2
STYCOM	8	28.13	24.22 32.03	1.9	8	95.63	47.50 143.07	25.3	8	4.50	1.82 7.19	35.4
TETSPI	10	32.00	26.91 37.09	3.3	13	593.00	-203.82 1388.83	328.9	0	0.00	0.00 0.00	0.0
UNDELL	3	3.67	2.89 4.45	1.1	3	4.00	7.64 5.36	2.7	3	1.00	1.00 1.00	0.0

TABLE IV-7

SPRING 1975 JUNIPER VEGETATION TYPE CHARACTERISTICS
MEAN, 90 PERCENT CONFIDENCE INTERVAL
AND ESTIMATED SAMPLE SIZE USING 4m^2 PLOTS

Species	Height (cm)				Cover (cm^2/4m^2)				Density (individual/4m^2)			
	NUM OBS	MEAN	90% C.I.	SAMPLE SIZE	NUM OBS	MEAN	90% C.I.	SAMPLE SIZE	NUM OBS	MEAN	90% C.I.	SAMPLE SIZE
ARTNOV	196	10.78	10.13 11.43	11.4	219	281.05	242.83 319.27	64.8	9	4.78	1.49 8.06	54.9
ARTTRI	6	28.17	18.64 37.69	7.9	8	386.25	36.86 735.64	81.9	0	0.00	0.00 0.00	0.0
ASTRAG	14	6.93	4.03 9.83	34.2	14	28.71	13.85 43.58	52.4	14	1.43	0.80 2.06	38.2
ATRCON	121	10.35	9.22 11.47	22.8	127	128.56	101.08 156.03	92.8	32	20.88	9.66 32.09	147.8
BARGRO	0	0.00	0.00 0.00	0.0	110	32143.54	30662.36 33624.72	3.7	0	0.00	0.00 0.00	0.0
BORAGE	7	9.71	6.71 12.72	8.1	7	60.86	29.64 92.08	22.2	7	9.57	-3.41 22.56	155.3
BORAGI	48	9.38	7.83 10.92	20.9	48	86.85	60.71 113.00	69.6	48	3.85	1.31 6.40	334.8
BROTEC	18	8.67	7.41 9.92	5.4	18	4.61	2.93 6.29	34.5	18	6.39	1.11 11.67	177.1
CHEALB	8	5.13	3.58 6.67	9.2	8	99.00	39.48 158.52	36.2	8	19.00	9.81 28.19	23.4
CHRGRE	46	14.87	12.79 16.95	14.4	48	288.67	201.17 376.16	70.6	5	2.80	1.46 4.14	12.1
CHRNAU	8	33.75	22.39 45.11	11.3	9	609.44	124.70 1094.19	73.4	0	0.00	0.00 0.00	0.0
CRUCIF	30	19.23	14.83 23.64	23.6	30	22.47	15.35 29.59	45.3	30	3.57	2.29 4.84	57.4
EPHVIR	3	21.00	4.47 37.53	14.5	3	280.00	-33.34 593.34	29.4	0	0.00	0.00 0.00	0.0
ERIGER	3	8.00	3.29 12.71	8.1	3	50.00	-20.59 120.59	46.7	3	3.00	0.28 5.72	19.2
ERIOGO	43	4.51	3.88 5.14	13.3	43	47.72	31.00 64.44	84.4	43	4.19	2.05 6.32	179.4
EUPHOR	34	1.91	1.55 2.28	12.6	34	22.29	16.06 28.53	42.6	34	2.21	1.80 2.61	18.2
FORNEI	3	7.00	3.41 10.59	6.2	3	140.00	50.92 229.08	9.5	0	0.00	0.00 0.00	0.0
GUTSAR	84	12.35	11.28 13.41	10.1	85	49.31	38.27 60.34	68.2	32	3.97	2.94 4.99	34.1
HEDBOR	35	26.69	24.66 28.72	3.2	38	339.87	265.85 413.89	28.8	35	1.97	1.50 2.45	32.4
HILJAM	46	8.59	7.88 9.29	4.9	46	455.11	278.87 631.35	110.4	46	24.72	13.91 35.53	140.7
HYMSCA	9	16.33	13.20 19.46	4.3	0	303.33	127.65 479.02	38.9	9	5.00	2.86 7.14	21.2
JUNOST	30	173.67	145.63 201.70	11.8	66	7319.92	5558.49 9081.36	61.1	1	1.00	1.00 1.00	0.0
KOCAME	46	4.85	4.37 5.32	7.0	46	30.02	23.66 36.39	33.1	43	2.47	1.91 3.02	34/4
LEPMON	30	29.40	26.31 32.49	5.0	30	49.43	32.16 66.71	55.1	30	3.03	2.15 3.92	38.4
LEPKAT	4	7.50	-1.40 16.40	53.6	4	105.00	-33.58 243.58	66.4	3	1.67	0.88 2.45	5.2
LITTER	0	0.00	0.00 0.00	0.0	109	1800.46	1283.27 2317.64	143.9	0	0.00	0.00 0.00	0.0
MENALB	3	12.00	2.20 21.80	15.6	3	33.33	0.92 75.74	22.3	3	7.00	-1.15 15.15	31.8
MULASP	4	9.25	4.78 13.72	8.9	4	15.00	15.00 15.00	0.0	4	1.75	0.15 3.35	31.8
ORYHYM	42	23.10	20.49 25.70	8.5	45	205.56	143.32 267.79	66.0	41	3.15	2.58 3.71	21.1
PHACEL	3	8.00	3.10 12.90	8.8	3	16.67	2.53 30.81	16.9	3	12.00	-3.67 27.67	40.0
PHLHOO	20	9.05	6.63 11.47	20.8	20	21.75	12.46 31.04	53.1	20	2.00	1.44 2.56	22.8
POAPRA	20	17.75	14.31 21.19	10.9	21	57.62	15.84 59.39	161.3	20	2.60	1.70 3.50	34.6
SARVER	3	61.00	-28.11 150.11	50.1	4	857.50	-29.63 1744.63	40.8	0	0.00	0.00 0.00	0.0
SISLIN	11	22.15	14.83 30.99	18.4	11	20.82	4.39 37.25	92.0	11	4.45	1.46 7.45	66.9
SITHYS	3	24.67	19.18 30.16	1.2	3	41.67	19.83 63.50	6.4	3	2.33	-0.80 5.47	42.4
SPIMUN	3	20.00	20.00 20.00	0.0	3	37.33	-24.44 99.10	77.3	3	1.00	1.00 1.00	0.0
STICOM	17	35.76	29.70 41.83	7.0	19	572.37	121.84 1022.90	169.9	17	8.00	2.57 13.43	113.9

TABLE IV-8

SPRING 1975 SHADSCALE VEGETATION TYPE CHARACTERISTICS MEAN, 90 PERCENT CONFIDENCE INTERVAL, AND SAMPLE SIZE USING 4m^2 PLOTS

Species	Height (cm)				Cover (cm^2/4m^2)				Density (Individual4m^2)			
	NUM OBS	MEAN	90% C.I.	SAMPLE SIZE	NUM OBS	MEAN	90% C.I.	SAMPLE SIZE	NUM OBS	MEAN	90% C.I.	SAMPLE SIZE
ALLIUM	9	11.56	7.02 16.09	17.8	9	5.33	1.54 9.12	58.6	9	1.44	1.00 1.89	10.9
ARTSPI	21	7.95	6.65 9.25	8.2	22	122.50	92.06 152.94	19.9	0	0.00	0.00 0.00	0.0
ARITRI	304	20.80	19.69 21.91	13.9	335	580.66	517.16 644.17	64.1	25	2.24	1.42 3.06	49.8
ASTRAG	15	2.73	1.73 3.74	28.5	15	14.07	6.91 21.22	54.7	15	1.53	1.12 1.95	15.4
ATRCON	504	15.44	14.82 16.07	13.4	539	311.28	284.12 338.44	65.6	60	4.93	3.83 6.04	48.2
BAIHUL	3	8.67	-1.71 19.04	33.6	3	11.67	-9.91 33.25	80.2	3	2.33	0.26 4.41	18.6
BARGRO	0	0.00	0.00 0.00	0.0	107	33638.16	32994.07 34282.28	0.6	0	0.00	0.00 0.00	0.0
BORAGI	21	7.24	5.69 8.78	14.0	21	11.71	8.30 15.13	26.0	21	8.90	4.83 12.98	64.2
BROTEC	69	13.45	12.39 14.51	6.9	69	1504.19	827.39 2180.99	223.5	69	639.97	359.00 920.94	212.8
CHOTEN	7	8.71	5.41 12.02	12.1	7	474.29	143.58 800.00	39.8	7	965.43	-95.60 2026.45	101.9
CHRGRE	6	28.50	19.27 37.73	7.2	6	670.83	235.93 1105.74	28.9	0	0.00	0.00 0.00	0.0
CHRVIS	7	28.14	14.11 42.17	21.0	8	763.25	78.50 1448.00	80.6	2	1.00	1.00 1.00	0.0
CRUCIF	34	23.68	19.71 27.64	15.3	34	46.32	19.62 73.03	180.8	34	3.82	2.69 4.96	48.0
ERIEFF	60	9.57	8.35 10.78	15.5	61	169.84	123.29 216.38	73.3	8	19.50	9.35 29.64	27.1
ERIGER	10	11.30	9.75 12.85	2.5	10	26.10	12.33 39.87	36.7	10	3.00	1.31 4.69	41.7
ERIOGO	40	2.48	1.93 3.02	31.2	40	49.10	18.44 79.76	249.6	34	11.76	8.29 15.24	47.4
EURLAN	4	12.50	8.10 16.90	4.7	4	66.25	18.30 114.20	20.0	0	0.00	0.00 0.00	0.0
GUTSAR	48	11.35	10.13 12.58	8.9	48	95.27	50.55 139.99	169.2	29	7.03	3.88 10.19	87.5
HALGLO	11	1.73	1.30 2.15	9.0	11	64.91	1.76 128.06	139.7	11	13.27	4.51 22.03	64.3
HILJAM	15	9.47	7.59 11.34	8.3	15	409.47	205.66 613.28	52.3	15	9.40	3.68 15.12	78.3
LEPMON	3	33.33	25.03 41.63	1.5	3	38.33	-34.30 110.95	84.2	3	1.33	0.55 2.12	8.1
LEPREO	19	6.37	5.50 7.24	5.1	19	23.11	7.73 38.49	121.9	19	33.63	9.93 57.29	136.1
LITTER	0	0.00	0.00 0.00	0.0	108	1216.71	976.07 1457.35	67.6	0	0.00	0.00 0.00	-0.0
MENALB	9	12.22	8.56 15.89	10.4	9	33.67	5.54 61.80	81.0	9	13.67	4.01 23.32	57.9
OENCAE	6	2.67	1.47 3.86	13.8	6	65.67	9.59 123.74	50.4	6	1.67	1.26 2.08	4.2
OPUNTI	28	7.71	7.00 8.42	3.5	28	177.61	50.33 304.88	215.1	19	2.00	0.71 3.29	114.2
ORYHYM	33	19.27	16.77 21.78	8.9	33	53.58	36.46 70.69	53.9	33	3.27	2.51 4.04	28.9
SALKAL	13	3.00	2.28 3.72	10.4	13	24.69	5.04 44.34	113.6	13	11.54	6.68 16.40	31.8
SARVER	10	23.03	16.64 29.36	10.1	11	342.73	116.39 569.07	64.1	1	1.00	1.00 1.00	0.0
SISLIN	3	26.33	8.60 44.06	10.6	3	12.33	-3.53 28.20	33.8	3	7.33	0.91 13.75	18.0
WITHYM	3	29.00	26.65 31.35	0.2	3	5.00	5.00 5.00	0.0	3	1.33	0.55 2.12	8.1
SITHYS	29	20.62	18.45 22.78	4.8	29	106.45	-36.87 253.76	780.8	29	2.79	1.91 3.67	43.3
SPHCOC	21	10.67	7.91 13.42	20.4	21	38.67	19.39 57.94	76.3	21	1.48	1.17 1.78	13.1
SPOAIR	5	14.20	10.10 18.30	4.4	5	149.00	23.55 274.45	37.8	5	1.60	0.79 2.41	13.5
STICOM	3	28.67	21.70 35.64	1.4	3	128.33	-19.91 276.58	31.3	3	6.00	2.41 9.59	8.4
SUADIA	5	20.20	15.81 24.59	2.5	5	85.00	50.83 119.17	8.6	0	0.00	0.00 0.00	0.0
SUATOR	6	24.00	13.61 34.39	10.9	5	122.00	11.01 232.99	44.1	1	5.00	5.00 5.00	0.0
TETSPI	56	23.98	21.18 26.78	12.2	61	403.46	258.98 547.94	114.9	3	1.67	0.10 3.24	20.8
UMBELL	3	2.67	0.59 4.74	14.2	3	10.67	-1.59 22.93	30.9	3	2.00	-0.35 4.35	32.5

TABLE IV-9

SPRING 1975 RIPARIAN VEGETATION TYPE CHARACTERISTICS MEAN, 90 PERCENT CONFIDENCE INTERVAL, SAMPLE SIZE USING 4m^2 PLOTS

Species	Height (cm)				Cover (cm^2/4m^2)				Density (individual/4m^2)			
	NUM OBS	MEAN	90% C.I	SAMPLE SIZE	NUM OBS	MEAN	90% C.I.	SAMPLE SIZE	NUM OBS	MEAN	90% C.I.	SAMPLE SIZE
GRREP	3	56.33	17.31 95.36	11.3	3	169.33	-162.10 500.77	83.9	3	7.33	3.18 11.48	7.5
GRSMI	41	42.93	39.14 46.71	5.1	41	297.44	230.51 364.37	33.2	41	18.46	11.11 25.82	104.1
OPSI	8	8.88	6.45 11.30	7.4	8	460.00	83.52 836.48	67.0	8	67.38	15.69 119.06	58.9
RTTRI	34	34.50	28.49 40.51	16.5	30	66.84	301.72 1031.96	182.3	5	7.00	-4.11 18.11	134.3
TRCAN	7	49.43	35.93 62.93	6.3	8	578.75	210.40 947.10	40.5	0	0.00	0.00 0.00	0.0
TRPAT	42	13.90	12.01 15.80	12.4	42	141.02	82.79 199.25	114.6	42	16.17	9.47 22.86	115.2
ARGRO	0	0.00	0.00 0.00	0.0	60	16623.25	13822.25 19424.25	27.3	0	0.00	0.00 0.00	0.0
ASHYS	7	8.14	5.94 10.35	6.2	7	102.86	51.21 154.50	21.3	7	57.71	0.71 114.71	82.3
ORAGI	11	11.00	8.06 13.94	10.5	11	54.45	20.87 88.04	56.1	11	55.45	-1.57 112.48	156.1
ROTEC	92	36.58	30.62 42.53	39.0	92	7221.75	5619.06 8824.44	72.5	92	1909.53	1471.10 2347.96	77.6
ELSAR	8	21.75	18.35 25.15	2.5	8	223.75	117.25 330.25	22.7	8	67.88	-5.69 141.44	117.6
CHIVIS	4	63.00	37.48 88.52	6.3	4	1327.50	-1076.49 3731.49	124.9	4	4.00	0.86 7.14	23.4
CHOTEN	11	12.27	8.82 15.72	11.7	11	111.82	47.57 176.06	49.7	11	217.55	25.34 409.75	115.2
CHRGE	4	39.00	23.26 54.74	6.2	4	930.00	274.37 1585.63	18.9	0	0.00	0.00 0.00	0.0
CHRNAU	25	46.36	33.85 58.87	27.0	29	1004.14	133.63 1874.65	326.8	12	2.58	0.92 4.25	67.8
CHRNAV	3	72.33	17.78 126.88	13.3	3	346.67	-197.64 890.97	57.8	3	1.00	1.00 1.00	0.0
CHRVIS	38	58.82	49.62 68.01	14.9	41	767.49	579.15 955.82	39.5	32	4.56	3.35 5.78	36.2
CLELUT	4	37.50	19.29 55.71	9.0	4	665.00	-1.77 1331.77	38.3	4	11.25	-0.47 22.97	41.4
CRUCIF	51	33.41	29.58 37.25	10.7	51	120.86	70.48 171.25	141.8	51	24.76	14.54 34.98	139.0
DISSPI	19	19.47	16.84 22.10	5.0	19	1015.16	215.96 1814.36	170.5	19	88.00	42.54 133.46	73.4
DISSTRA	16	17.19	14.47 19.91	5.7	17	706.76	464.46 949.06	28.6	17	84.29	53.24 115.35	33.0
EQUARV	4	29.75	26.34 33.16	0.5	4	110.50	-35.10 256.10	66.1	4	98.50	-40.52 237.52	75.9
FESOCT	7	12.86	7.30 18.41	15.7	7	39.57	15.16 63.98	32.1	7	35.71	7.76 63.67	51.7
IVAAXI	22	16.86	14.78 18.95	4.9	22	278.09	110.22 445.96	117.7	22	43.05	22.39 63.70	74.4
JUNBAL	5	54.40	45.65 63.15	1.4	5	14.60	-3.64 32.64	83.2	5	4.60	1.57 7.63	23.1
KOCHIA	9	10.89	8.57 13.20	5.2	9	1327.22	-113.07 2767.52	136.5	9	305.11	-88.00 698.22	192.5
LEPIDI	7	13.14	8.76 17.53	9.4	7	719.43	-166.44 1605.30	127.9	7	72.86	-1.58 147.30	88.1
LEPPER	14	19.93	15.42 24.44	10.0	14	249.21	1.22 497.21	193.5	14	349.14	-106.16 804.45	332.3
LEPREO	19	22.84	17.57 28.11	14.7	19	23.68	5.67 41.70	159.1	19	27.53	11.29 43,77	95.8
LITTER	0	0.00	0.00 0.00	0.0	108	20604.69	18483.41 22725.94	18.3	0	0.00	0.00 0.00	0.0
MELOFF	37	16.05	11.47 20.64	48.3	39	1194.87	581.32 1808.42	160.3	37	89.08	42.08 136.08	164.8
POAPRA	14	64.43	55.53 73.33	3.7	14	1150.71	226.92 2074.51	125.9	14	44.86	18.27 71.44	68.6
POPFRE	11	926.62	254.27 1599.37	77.7	30	13282.33	8823.76 17740.91	50.8	6	2.50	0.64 4.36	39.1
SALEXI	13	152.31	108.32 196.30	15.0	17	4088.94	1482.86 6695.02	98.7	12	3.75	2.15 5.35	29.7
SALKAL	13	10.23	7.32 13.14	14.6	13	149.62	35.01 264.22	105.3	13	34.62	-1.89 71.12	199.5
SALVER	11	77.45	50.84 104.07	17.4	12	5623.33	654.09 10592.56	127.7	2	1.00	1.00 1.00	0;0
SPOAIR	5	19.20	11.68 26.72	8.2	5	620.00	201.43 1038.57	24.3	5	5.00	-2.57 12.57	122.1
TAMPEN	13	217.62	169.53 265.70	8.6	17	2420.80	1025.83 3815.94	69.7	11	6.00	2.43 9.57	52.2
TAROFF	10	22.40	12.47 32.33	25.9	10	106.00	55.80 156.20	29.6	10	4.80	1.42 8.18	65.5
TRADUB	6	33.33	21.78 44.89	12.0	6	18.17	-9.79 46.12	102.9	6	2.50	0.64 4.36	39.1

Artemisia tridentata, *Chrysothamnus viscidiflorus*, *Guterrizia sarothrae*, *Artemisia nova*, *Atriplex confertifolia*, *Hedysarum boreale*, *Juniperus osteosperma*, *Agropyron smithii* and *Populus fremontii*. Some examples of species infrequently sampled or difficult to estimate are *Cryptantha* spp., *Bromus tectorum*, *Sarcobatus vermiculatus*, *Eurotia lanata*, and *Astragalus* spp.

The large amount of bare ground--34,951 cm^2 per 4-m^2 plot in the sagebrush/greasewood type--attested to the relatively low plant density of this type. Low plant density was also seen in the juniper type (32,143 cm^2), and in the shadscale type (33,638 cm^2). In the riparian type the amount of bare ground was 16,623 cm^2, about half that of the other three types because of the dense stands of downy brome, *Bromus tectorum*, annual mustards, yellow blossom sweet clover (*Melilotus officinalis*), and western wheatgrass (*Agropyron smithii*).

The amount of cover for all species averaged over the 100 plots in each vegetation type, regardless of whether that species was found in all plots, was calculated for an estimate of total vegetative cover of each type. In some cases the total plant cover appeared high because of the overlapping canopy of various plant layers. The average plant cover of each vegetation type in June 1975 was sagebrush/greasewood, 12.0; juniper, 16.7; shadscale, 12.7; and riparian, 37.8 percent. These values are relatively high because they include the cover of annual species that were abundant in the spring of 1975.

Vegetation Parameters, Fall 1975

Vegetation attributes sampled in the September field inventory were similar to those of earlier inventories except for the differences in seasonal effects. Plant heights were not generally different from those recorded in the spring except for a few species that produced elongated stems in response to the favorable growing conditions (Tables IV-10, IV-11, IV-12, and IV-13). For example, the average height of *Artemisia tridentata* in June 1975 was 20 cm (8 in.) and in September it was 29 cm (11 in.) in the shadscale vegetation type, *Guierrezia sarothrae* was 11 cm (4 in.) in spring and 20 cm (8 in.) in fall, and *Tetrademia spinescens* was 32 cm (13 in.) in spring and 33 cm (13 in.) in fall. Plant height is related to micro-environment. Many of the shrubs produce new twig growth within the canopy, which either dies back or is consumed by animals. The net result is that after maturity plants generally maintain a characteristic height in relation to favorability of a given site. Thus, on the

TABLE IV-10

FALL 1975 SAGEBRUSH/GREASEWOOD VEGETATION CHARACTERISTICS

Species	Height (cm)				Cover (cm²/4m²)				Density (individual/4m²)			
	NUM OBS	MEAN	90% C.I.	Sample Size	NUM OBS	MEAN	90% C.I.	Sample Size	NUM OBS	MEAN	90% C.I.	Sample Size
ARTFRI	1	43.0	- -	-	1	600.0	- -	-	1	1.0	- -	-
ARTSPI	13	9.8	11.9 7.7	11.7	7	249.3	352.8 145.8	20.6	7	2.4	4.5 0.3	89.8
ARTTRI	136	29.2	31.1 27.3	12.9	64	2395.9	2850.8 1941.1	52.4	64	5.1	6.5 3.8	99.0
ASTRAG	1	4.0	- -	-	1	25.0	- -	-	1	1.0	- -	-
ATRARG	-	-	- -	-	1	75.0	- -	-	1	14.0	- -	-
ATRCON	399	24.6	32.8 16.4	1008.0	94	2241.7	2524.7 1958.7	34.0	94	8.8	10.3 7.3	63.1
ATRPOW	-	-	- -	-	1	30.0	- -	-	1	1.0	- -	-
BARGRO	20	1.0	- -	-	100	33803.9	34489.0 33118.7	0.9	100	1.0	1.0 1.0	-
CHRGRE	21	26.5	28.7 24.3	3.0	13	869.2	1426.7 311.6	104.8	13	2.2	3.2 1.2	54.9
ERIEFF	38	23.1	25.6 20.6	15.9	15	400.0	648.4 151.6	115.7	15	6.9	9.1 4.8	28.4
ERIENG	22	16.1	19.2 3.3	16.3	24	330.1	39.7 20.5	51.1	24	4.9	6.5 3.2	57.6
ERIOGO	3	16.3	29.4 3.3	21.3	3	15.0	21.8 8.2	6.8	3	11.7	30.9 -7.6	90.5
EURLAN	8	11.5	14.4 8.6	9.0	6	78.3	126.9 39.8	37.5	6	1.8	2.8 0.9	25.0
GRASPI	2	43.5	- -	-	3	866.7	- -	-	3	1.0	- -	-
GUTSAR	36	19.7	21.4 18.0	6.1	37	238.4	458.6 18.1	717.8	37	7.5	10.3 4.6	123.2
HALGLO	0	-	- -	-	5	400.0	1206.0 -406.0	308.3	5	42.4	82.1 2.7	66.3
HILJAM	9	23.7	33.7 13.6	29.5	9	575.0	1079.3 270.7	59.1	9	10.9	16.0 5.8	36.1
OPUNTI	20	7.6	8.6 6.6	7.2	13	282.3	435.2 129.4	74.7	13	1.6	2.2 1.1	29.6
OPUSPP	3	5.7	9.8 1.5	17.9	1	525.0	- -	-	1	3.0	- -	-
ORYHYM	28	20.8	23.4 18.2	9.2	28	279.8	671.9 -112.4	1168.8	28	5.9	11.3 0.6	458.4
SALKAL	-	-	- -	-	5	-	- -	-	5	15.8	24.0 7.6	20.4
SARVER	22	33.1	40.6 25.6	23.5	13	1286.4	1890.1 682.7	56.1	13	1.9	2.4 1.4	17.9
SITHYS	2	21.0	- -	-	2	70.0	- -	-	2	3.0	- -	-
SPHCOC	14	18.1	21.9 14.4	12.0	14	47.7	68.4 27.0	52.4	14	2.8	3.9 1.7	46.5
SPHPAR	2	21.5	- -	-	2	20.0	- -	-	2	1.5	- -	-
SPOAIR	2	7.0	- -	-	2	825.0	- -	-	2	7.5	- -	-
STICOM	10	46.9	55.0 38.8	5.6	10	139.5	263.9 15.1	148.8	10	2.2	3.0 1.5	22.0
SUASUE	5	31.6	43.0 20.3	9.7	5	180.0	393.4 -33.4	106.4	5	1.6	2.4 0.8	19.2
TETNUT	6	35.0	45.8 24.3	9.2	2	2987.5	- -	-	2	4.0	- -	-
TETSPI	20	33.3	38.4 28.3	9.5	15	990.7	1575.2 406.1	104.5	15	2.0	2.7 1.3	32.9

Data are for the number of observations, mean, 90% confidence interval about the mean and sample size required to estimate within 25% of the mean with a 90% statistical confidence.

TABLE IV-11

FALL 1975 JUNIPER VEGETATION TYPE CHARACTERISTICS

Species	Height (cm)				Cover (cm^2/4m^2)				Density (individual/4m^2)			
	NUM OBS	MEAN	90% C.I.	Sample Size	NUM OBS	MEAN	90% C.I.	Sample Size	NUM OBS	MEAN	90% C.I.	Sample Size
ARTNOV	115	17.4	19.1 15.8	16.7	42	852.1	1103.2 600.9	58.4	42	4.7	5.8 3.7	32.9
ARTTRI	30	25.2	30.0 20.3	16.9	18	618.8	915.8 321.9	59.7	18	2.0	2.5 1.5	17.8
ASTRAG	5	24.0	33.7	8.8	6	326.0	599.4 52.5	48.4	6	1.3	1.7 .9	6.5
ATRCON	27	18.1	22.6 13.7	23.9	19	282.4	407.0 157.8	53.6	19	1.9	2.6 1.2	38.7
BARGRO	0	-	- -	-	100	32799.7	34495.0 21103.0	4.3	0	-	- -	-
BOUGRA	1	30.0	- -	-	1	25.0	- -	-	1	1.0	- -	-
CHRGRE	8	19.4	25.4 13.4	9.7	6	195.0	455.4 -65.4	122.7	6	1.8	2.9 .8	22.8
CHRVIS	11	24.0	30.1 17.9	9.4	9	801.1	1244.0 357.0	35.5	9	1.3	1.6 1.0	6.1
CRUCIF	6	9.0	16.4 1.6	46.4	6	5.2	7.6 2.7	15.2	6	1.3	1.9 .7	16.2
CRYPTA	33	9.4	11.2 7.5	-	33	82.2	98.9 65.6	-	33	2.7	3.4 2.0	-
EPHVIR	5	18.4	24.8 12.0	6.4	5	146.0	276.8 15.1	43.0	5	1.2	1.6 .8	6.0
ERIGER	7	21.7	30.9 12.5	15.2	7	49.3	75.3 23.1	23.8	7	1.7	2.2 1.2	8.4
ERINIC	22	13.9	15.7 12.1	5.4	23	68.8	111.7 25.9	131.7	23	2.0	2.7 1.5	28.8
ERIOGO	9	13.1	16.3 9.8	7.3	10	33.0	46.2 19.7	21.2	10	2.8	3.7 1.9	13.3
ERIOVA	10	4.2	5.1 3.3	6.4	10	25.4	36.2 14.6	24.0	10	3.9	6.6 1.1	65.4
EUPFEN	22	4.3	5.0	8.3	22	56.4	73.8 38.9	31.0	22	1.8	2.2 1.4	13.3
EUPROP	7	5.4	7.5 3.3	12.7	7	69.8	99.5 40.2	15.2	7	2.1	2.9 1.4	10.8
GRASPI	0	-	- -	-	1	300.0	- -	-	1	1.0	- -	-
GUTSAR	52	17.3	18.8 15.7	6.6	51	61.4	73.7 49.0	33.0	51	2.5	3.2 1.9	53.0
HALGLO	1	4.0	- -	-	2	201.0	782.0	84.0	2	1.0	- -	-
HEOBOR	5	24.2	28.9 19.5	2.0	5	420.0	721.0 118.0	27.0	5	2.2	3.3 1.0	15.8
HILJAM	12	12.5	15.9 9.2	11.5	12	1243.0	2679.0 193.0	218.0	12	20.6	31.0 10.3	41.0
JUNOST	21	171.4	214.1 128.9	18.0	56	8569.3	11086.0 5052.0	77.0	56	1.1	1.1 1.0	4.3
KOCAME	1	15.0	- -	-	1	150.0	- -	-	1	1.0	- -	-
LEPPUN	3	4.3	5.9 2.8	3.1	3	18.3	28.7 7.9	7.0	3	2.3	3.1 1.5	2.7
LITTER	0	-	- -	-	58	546.0	800.4 292.6	-	58	-	- -	-
OPUPOL	1	8.0	- -	-	1	200.0	- -	-	1	2.0	- -	-
ORYHYM	17	25.1	31.0 19.2	13.0	18	92.0	137.5 46.5	63.0	18	5.6	10.2 1.0	17.4
PETPUM	19	14.7	17.4 11.9	9.0	16	197.2	311.5 83.0	76.0	16	4.0	6.1 1.9	62.0
PHLHOO	13	4.9	6.3 3.5	14.0	13	93.7	157.2 30.3	82.0	13	2.5	3.4 1.6	23.0
PINEDU	1	40.0	- -	-	1	100.0	- -	-	1	1.0	1.0 1.0	-
POASEC	6	36.6	46.9 26.4	5.4	6	570.0	897.0 244.0	22.5	6	19.2	13.5 4.7	16.0
RANTES	2	8.5	15.8 1.2	7.5	2	17.5	39.4 -4.4	15.0	2	1.0	1.0 1.0	-
SITHYS	2	21.0	32.6 9.3	3.0	2	35.0	78.8 -8.8	15.9	2	2.5	6.8 1.8	31.2
STALIT	0	-	- -	-	68	1560.0	2212.0 908.0	189.0	68	-	- -	-
STICOM	20	21.6	25.9 17.3	11.0	20	42.6	60.9 24.2	54.0	20	1.7	2.1 1.3	16.0

Data are for the number of observations, mean, 90% confidence interval about the mean and sample size required to estimate within 25% of the mean with a 90% statistical confidence.

TABLE IV-12

FALL 1975 SHADSCALE VEGETATION CHARACTERISTICS

Species	Height (cm)				Cover ($cm^2/4m^2$)				Density (individual/$4m^2$)			
	NUM OBS	MEAN	90% C.I.	Sample Size	NUM OBS	MEAN	90% C.I.	Sample Size	NUM OBS	MEAN	90% C.I.	Sample Size
AMBPSI	1	47.0	- -	-	1	100.0	- -	-	1	1.0	- -	-
ARTNOV	81	16.5	18.1 14.9	17.9	22	1697.7	2485.7 909.7	69.6	22	4.6	5.6 3.7	13.0
ARTSPI	22	8.5	9.7 7.2	6.8	5	985.0	2127.6 -157.6	71.7	5	6.6	15.0 -1.8	86.3
ATRTRI	160	29.2	31.1 27.3	10.0	47	2773.9	3324.5 2223.4	29.6	47	4.9	5.8 4.1	23.2
ASTRAG	4	5.5	9.1 1.9	15.7	5	30.4	66.1 -5.3	73.6	5	4.2	7.4 .9	31.2
ATRCON	46	18.9	20.9 16.9	8.4	26	509.0	640.7 378.8	25.7	26	2.2	2.7 1.7	21.8
BARGRO	-	-	- -	-	99	22715.5	29046.9 26384.1	3.7	99	1.0	1.0 1.0	-
CHRGRE	56	32.3	34.8 29.7	5.5	28	1366.4	1872.5 860.3	57.5	28	3.2	4.4 2.1	54.2
CHRNAU	2	56.0	- -	-	2	4000.0	- -	-	2	1.0	- -	-
EPHVIR	1	25.0	- -	-	2	150.0	- -	-	2	1.0	- -	-
ERIENG	6	20.0	24.2 15.8	4.1	6	43.3	76.4 10.2	40.0	6	1.2	1.4 .8	5.0
ERIOGO	12	17.3	19.6 15.0	4.1	13	93.5	130.7 56.2	40.4	13	1.6	2.1 1.1	25.7
EURLAN	8	22.5	30.0 14.9	11.3	7	276.4	452.1 100.8	34.1	7	1.3	1.8 .7	15.0
GRASPI	60	35.0	37.4 32.5	4.7	29	2360.7	3029.4 1692.0	33.6	29	2.3	2.7 1.7	26.3
GUTSAR	14	19.9	22.8 17.0	4.2	14	293.9	450.1	55.2	14	4.9	7.8 2.0	68.1
HILJAM	10	22.4	27.3 17.4	6.3	10	464.0	676.1 251.9	27.5	10	8.5	10.8 6.1	10.3
HYMENO	1	5.0	- -	-	2	75.0	- -	-	2	2.0	- -	-
LEPMON	3	43.3	53.7 32.9	1.3	3	500.0	500.0 500.0	-	3	3.6	4.4 2.9	1.1
OPUNTI	2	6.5	16.7 -3.7	25.1	2	110.0	- -	-	2	1.0	- -	-
ORYHYM	50	45.4	48.3 42.6	3.1	49	668.6	812.7 524.3	36.5	49	105.8	373.1 -61.8	1968.1
SARVER	60	49.1	55.2 42.7	15.1	40	2475.6	3288.8 1662.5	69.1	40	2.1	2.6 1.5	44.1
SITHYS	6	23.2	29.2 17.1	4.7	5	155.0	272.3 37.5	30.6	5	1.2	1.6 .8	6.0
SPHCOC	4	20.0	31.7 8.2	8.1	4	185.0	555.9 -185.1	34.3	4	2.0	4.3 -.3	32.5
SPOCRY	3	28.3	36.2 20.5	1.8	3	158.3	325.8 -9.2	26.3	3	1.7	3.2 .1	20.8
STALIT	-	-	- -	-	99	7381.6	8636.1 5885.1	65.1	99	1.0	- -	-
STICOM	39	60.5	64.5 56.7	2.6	39	976.9	1249.4 304.7	47.2	39	13.6	16.9 10.3	35.9
SUAEDA	6	45.1	57.3 32.7	5.1	3	341.7	427.1 256.2	1.5	3	2.0	3.4 .6	10.8
TETSPI	6	34.6	42.6 26.7	3.6	6	708.3	1153.8 262.8	27.2	6	1.0	1.0 1.0	-

Data are for the number of observations, mean, 90% confidence interval about the mean and sample size required to estimate within 25% of the mean with a 90% statistical confidence.

TABLE IV-13

FALL 1975 RIPARIAN VEGETATION CHARACTERISTICS

Species	Height (cm)				Cover (cm²/4m²)				Density (Individual/4m²)			
	NUM OBS	MEAN	90% C.I.	Sample Size	NUM OBS	MEAN	90% C.I.	Sample Size	NUM OBS	MEAN	90% C.I.	Sample Size
AGRSMI	24	76.4	86.4 66.4	6.1	24	1033.7	1948.7 118.8	270.0	24	13.8	23.5 4.2	172.0
AMBPSI	5	36.4	78.1 -6.1	72.1	5	190.1	477.1 -96.3	120.0	5	9.2	20.9 -2.5	85.1
ARTLUD	1	47.1	- -	-	1	350.0	- -	-	1	1.0	- -	-
ARTTRI	6	54.3	88.1 20.5	26.6	6	890.0	1479.9 300.1	30.2	6	3.5	6.5 .4	53.4
ATRCAN	2	37.1	121.6 -47.7	53.1	3	1351.7	3749.1 1046.0	73.1	3	1.0	1.0 1.0	-
ATRCON	1	85.1	- -	-	1	120.0	- -	-	1	-	- -	-
ATRPAT	21	39.7	50.5 28.9	22.1	21	170.5	221.1 119.1	27.1	21	9.5	14.7 4.3	90.0
ATRFOW	1	28.1	- -	-	1	100.1	- -	-	1	1.0	- -	-
BARGRO	-	-	- -	-	100	6537.5	8374.1 4700.0	-	100	1.0	- -	-
CHRNAU	24	84.4	94.8 74.1	5.3	27	2289.2	3800.7 777.8	175.7	27	1.6	2.1 1.3	16.8
CHRVIS	45	87.2	99.1 75.2	13.4	46	2277.8	3013.0 1541.0	76.8	46	5.9	7.4 4.5	42.3
CIRSIU	3	6.0	34.6 5.4	5.4	3	425.0	498.0 352.0	.3	3	6.5	7.9 5.0	.5
CLELIG	2	15.0	- -	-	2	310.0	- -	-	2	1.0	- -	-
CLESER	2	50.0	- -	-	2	200.0	- -	-	2	2.5	- -	-
COMPAL	11	25.2	30.4 19.9	6.4	11	727.7	1219.0 236.0	67.3	11	32.3	47.0 17.0	31.2
DESSUP	1	22.0	- -	-	1	5600.0	- -	-	1	1.0	- -	-
DIFFDI	1	27.0	- -	-	1	1000.0	- -	-	1	-	- -	-
DISSPI	48	23.4	25.4 21.5	5.5	48	1405.0	1843.0 967.0	74.6	48	53.4	68.1 38.6	58.4
EQUARY	6	48.8	70.8 26.8	13.9	6	2929.0	6590.0 -731.0	107.0	6	324.8	528.7 66.9	43.0
GRISQU	1	37.0	- -	-	3	35.0	68.9 1.0	49.0	3	3.0	7.7 -1.7	128.0
GUTSAR	1	37.0	- -	-	1	20.0	- -	-	1	1.0	- -	-
JUNBAL	5	52.6	81.7 23.4	16.4	5	176.0	313.8 38.2	32.7	5	74.4	137.3 11.5	38.1
KELOFF	25	17.5	21.4 13.7	25.6	25	629.9	868.8 391.0	75.7	25	56.6	85.5 27.0	136.0
KUHASP	2	54.0	- -	-	2	10500.0	- -	-	2	178.0	- -	-
OPUNTI	1	6.0	- -	-	1	30.0	- -	-	1	1.0	- -	-
PHRCOM	3	153.3	282.4 24.2	16.6	3	960.0	2072.0 -152.0	31.5	3	44.3	103.5 -14.8	41.0
POAPRA	5	45.25	83.4 7.1	27.1	5	2925.0	5698.4 151.5	34.2	5	94.0	159.6 38.4	18.0
POPFRE	14	1300.4	1825.7 775.1	31.9	31	20898.0	25836.0 15961.0	27.7	31	2.5	3.4 1.7	56.9
SHUTRI	1	13.0	- -	-	1	15.0	- -	-	1	2.0	- -	-
ROSWOO	1	32.0	- -	-	1	350.0	- -	-	1	2.0	- -	-
SALEXI	12	280.7	464.9 96.4	70.5	13	4725.4	8055.2 1394.5	89.1	13	2.5	3.2 1.7	16.2
SALKAL	16	32.3	39.8 25.0	9.2	16	920.2	1460.2 380.2	78.2	16	48.9	77.2 20.6	75.8
SARVER	9	103.4	143.3 63.6	33.0	12	7007.0	1229.5 1719.0	206.0	12	1.7	2.5 .7	109.0
SENECI	1	98.0	- -	-	1	950.0	- -	-	1	17.0	- -	-
SPOAIR	3	40.0	67.1 12.8	10.8	3	1350.0	3537.0 -837.0	61.7	3	1.7	3.2 .1	20.1
SSTALI	0	-	- -	-	1	16000.0	- -	-	1	1.0	- -	-
STALIT	0	-	- -	-	99	27661.0	29666.0 25656.0	8.3	99	1.0	- -	-
TAMPEN	10	306.7	464.8 148.6	77.8	13	4400.0	6101.0 2641.0	65.3	13	2.3	3.5 1.1	115.4
TAROFF	1	6.0	- -	-	1	1300.0	- -	-	1	-	- -	-

Data are for the number of observations, mean, 90% confidence interval about the mean and sample size required to estimate within 25% of the mean with a 90% statistical confidence.

west-facing slopes of the shadscale type, the typical shrub vegetation is about 20 cm (8 in.) high, whereas in the sagebrush/greasewood type the dominant plants are 30 cm to 33 cm (12 in. to 13 in.) high. In the juniper type the average height of juniper is 172 cm (68 in.), but the understory shrubs and grasses are about 15 cm (6 in.)

Plant cover is a variable attribute of vegetation and is related to plant age and size and to the natural aggregation of species into groups. The large amount of open space adds variability to data for plant cover, and therefore many sampling plots are required. The mean cover of species listed in Tables IV-10 through IV-13 represent the average amount of cover in the 4-m^2 plots. The tables also give an estimate of the average amount of cover that is characteristic of the various species. For example, the average cover of sagebrush in a 4-m^2 plot is 2,396 cm^2 but the plot is occupied by several plants.

Because the values in Tables IV-10 through IV-13 represent only the plots in which species occurred, a simple total would give an over-estimation of the cover of that species. By considering the cover values on the basis of the total number of plots sampled (using 100 as a divisor), the general values for the percentage of plant cover are as follows: sagebrush/greasewood, 11.4 percent; juniper, 7.5 percent; shadscale, 9.6 percent; and riparian, 15.3 percent. Individual species values are a part of the total and are generally very small except for the dominant species such as juniper, sagebrush, and Fremont poplar.

Plant density is calculated by determining the number of plants per unit area. The data in Tables IV-10 through IV-13 give the number of plots in which the various species occurred and the average number of plants in those 4-m^2 plots. Some typical plant densitites in the sagebrush/greasewood type are *Artemisia tridentata*, 5.1; *Chrysothamnus greenii*, 2.2; *Eurotia lanata*, 1.8; *Sarcobatus vermiculatus*, 1.9; and *Stipa comata*, 2.2. In the juniper type some typical densities are *Cryptantha* spp, 2.3; *Gutierrizia sarothrae*, 1.7; *Juniper osteosperma*, 1.1; and *Hillaria jamesii*, 4.0. Some typical densities in the shadscale type are *Atriplex confertifolia*, 2.2; *Chrysothamnus greenii*, 3.2; *Grayia spinosa*, 2.3; and *Sitanion hystrix*, 1.2. In the riparian type densities of understory species such as *Agropyron smithii* 13.8; *Distichlis stricta* 53.4; and *Comandra pallida* 32.3 indicate a large number of plants in a given area. The overstory of Fremont poplar (*Poplus fremontii*) in the White River flood plain is considered dense at 2.5 plants per plot; however, when considering the total number of plots sampled (100), the density of Fremont poplar is 0.14 plants per 4-m^2.

d. Conclusions

At this point, conclusions are only tentative, and further observations are required for interpretation. Height, cover, and density of annuals are subject to change each season because of changing environmental conditions, especially precipitation.

Statistical reliability of sampling is a requirement of the baseline study, but is realistic only for the dominant (and frequently-occurring) plant species. For example, in the sagebrush/greasewood vegetation type, 136 Artemisia tridentata plants were measured for height in the fall 1975 sampling period; and because this is a relatively uniform characteristic, the mean height of 29.2 cm (11.4 in.) varies from 27.3 cm (10.6 in.) to 31.1 cm (12.1 in.) in 90 percent of the cases. To sample sagebrush height within 25 percent of the mean of a 90 percent statistical reliability, 12 samples are required. Thus, the 136 observations made were more than an adequate sample. Where 64 plots sampled had sagebrush in them, the mean cover of sagebrush was 2,395 cm^2 (371 $in.^2$) with a 90 percent confidence interval about this mean ranging from 1,941 cm^2 (301 $in.^2$) to 2,840 cm^2 (440 $in.^2$). Under these conditions 52.4 samples would be required to estimate within 25 percent of the mean with a statistical reliability of 90 percent. Sixty-four plots out of 100 contained sagebrush with an average density of 5.1 and a confidence interval ranging from 3.8 to 6.5. Because of a greater variability in density, possibly from a plant aggregation effect, 99 plots would be required for statistical adequacy in a fall period. Sampling is therefore inadequate when only one or two plants of a species are counted because such a small sample does not provide enough information for statistical calculations.

Species with high variability, such as Eurotia lanata (the name has recently been changed to Ceratoides lanata), are an example of the sampling dilemma. Within the 100 plots sampled in fall 1975 in the sagebrush/greasewood vegetation type, eight height measurements of Ceratoides were recorded, but nine are required for statistical adequacy. Cover was estimated in six plots, but the cover was so variable that 37.5 plots would be required for statistical adequacy. The density of Ceratoides was counted in six plots, but 25 would be required to adequately describe its density.

e. Work Scheduled

Vegetation will be sampled in spring 1976 for community structure and composition, and other aspects will be observed in summer and fall. All data will be pooled to make statistical comparisons.

3. PHENOLOGICAL CHARACTERISTICS

a. Objectives

Phenological data are being collected to record stages of plant development as a basis for interpreting aerial photographs of plant conditions.

b. Methodology

Plant development is being observed by species in six key periods of the year. The development will be recorded in each of five 36-m^2 (400-ft^2) plots per vegetation type. Plant development will be observed according to a computer-based code consisting of 22 possible phenological stages. The computer will be used to obtain average conditions of species for each date observed.

c. Summary of Results

In early March, 1975, virtually all species observed, except two herbaceous plants, *Solidago vigida* and *Lepidium watsonii*, were in a state of winter dormancy. By mid-April most species, except three grasses, *Agropyron smithii*, *Oryzopsis hymenoides* and *Hilaria jamesii* and two trees, *Salix exigua* and *Tamarix pentandra*, had begun spring growth. By mid-May the leaves of most species were well-expanded and flower initiation had begun in such species as *Astragalus* spp., *Bromus tectorum*, *Populus fremontii*, *Grayia spinosa*, *Tetradymia spinescens*, *Sphaeralcea coccinia*, *Artemisia spinescens*, and several species of crucifereae. Near the end of June the annual grass, *Bromus tectorum*, was completing its life cycle and starting to dry while at the same time the flower stalks of *Artemisia tridentata* and *Artemisia nova* were in the process of elongation. *Cleome lutea*, *Grayia spinosa*, *Aster* spp., *Erogonum* spp. and *Solidago rigida* were in full bloom. In August

Chrysothamnus greenii, Guterrizia sarothrae, Chrysothamnus nauseosus were flowering and the seeds of Agropyron smithii, Oryzopsis hymenoides, Hilaria jamesii, Astragalus spp. and Stipa comata were nearing maturity or beginning to disseminate. Grayia spinosa was in the stage of fall leaf senescence. By the end of October most species were in or entering a stage of winter dormancy. Seed dissemination of Artemisia tridentata and Artemisia nova was in progress and such species as Populus fremontii and Salix exigua were losing their leaves.

d. Conclusions

No conclusions can be made at this time.

e. Work Scheduled

The first season of phenological observations will be completed in March 1976. Observations will be continued until plant dormancy in late fall 1976.

4. PRODUCTIVITY

a. Objectives

The productivity assessment of each vegetation type is conducted to determine the production of annual and perennial species and to determine the productivity potential of the site.

b. Methodology

In the fall sampling periods, productivity was measured only for the perennial species. For shrubs and juniper trees, data were obtained by clipping current year's growth from a 100-cm^2 (1-in.^{2}) area and multiplying the value thus obtained by the cover value of that species in the plot sampled. The production of annual species in 1975 was measured during the vegetation field studies of June 9 to 13. All annual grasses and forbs were clipped from a 2,500 cm^2 (400 in.^{2}) quadrat, dried, and weighed.

c. Summary of Results

Fall 1974 productivity by species in each vegetation type is given in Table IV-14. In the sagebrush/greasewood type, sagebrush, Russian thistle, Sporobolus spp. and greasewood accounted for most of the current year's production. In the juniper type, Hillaria jamesii and juniper were the main sources of production. Big sagebrush, black sagebrush, horsebrush, and greasewood accounted for a large portion of the 1975 production in the shadscale type. Production of perennials in the riparian type was primarily confined to salt cedar, rabbitbrush greasewood, and sagebrush. Fremont poplar, because of its size, far exceeded the production of other species.

In spring 1975, production of annuals was enhanced by the frequent and regular rainfall in spring 1975, resulting in abundant plant growth of both annual and perennial species (Table IV-15). Flowers were abundant on all species, and there was greater than average vegetative growth and a large amount of seed production at the end of each species' growing season. New-stem growth of shrubs in the area appeared to be far greater than that generally observed in several previous years.

The results indicate that a considerable difference in production of annual plant material exists among the four vegetation types. The greatest production of annual plant material occurred in the riparian type, which in 1975 produced about 590 grams per square meter, 90 percent of which was grass. The second most productive type was the shadscale, which produced about 224 grams per square meter, 77 percent of which was grass. Third in productivity was the sagebrush/greasewood vegetation type, which produced 51 grams of plant material per square meter in 1975, 94 percent of which was grass. The least productive understory vegetation was in the juniper vegetation type, which produced only 8.8 grams per square meter in 1975, 86 percent of which was grass. The juniper type is well known for its paucity of understory vegetation, caused by the allelopathic effect of the litter cover, which originates from the juniper tree. Even in a favorable precipitation year such as 1975 there was little production of annual species under the juniper canopy.

Understory species, mostly annuals, produced large amounts of growth that turned to standing and fallen litter at the end of the spring growing season, possibly creating a fire hazard; however, the concentration of the annual species as understory of shrubs rather than as a uniform layer over the entire area would serve as a barrier to the spread of any wildfire.

TABLE IV-14

FALL 1974 PRODUCTION OF PERENNIAL SPECIES OF EACH OF FOUR VEGETATION TYPES

Shadscale					Riparian					Sagebrush/Greasewood					Juniper				
		Dry Matter (kg/4m2)					Dry Matter (kg/4m2)					Dry Matter (kg/4m2)					Dry Matter (kg/4m2)		
Species	Num Obs	Mean	90% C.I.	Sample Size	Species	Num Obs	Mean	90% C.I.	Sample Size	Species	Num Obs	Mean	90% C.I.	Sample Size	Species	Num Obs	Mean	90% C.I.	Sample Size
AGRSMI	1	0.010	0.010 0.010	-	AGRSMI	23	0.170	0.101 0.239	55.8	AMBPSI	2	0.055 0.126	0.044	2.3	AGRSMI	3	0.051	0.008 0.095	16.8
ARTLUD	1	0.015	0.015 0.015	-	AMBRSI	5	0.042	-0.012 0.095	87.2	ARTNOV	30	0.302 0.436	0.168	88.3	ARTLUD	27	0.072	0.035 0.109	107.6
ARTNOV	27	0.551	0.313 0.569	89.3	ARTLUD	1	4.435	4.435 4.435	-	ARTTRI	34	0.414	0.302 0.526	39.8	ARTNOV	56	0.217	0.160 0.274	61.7
ARTTRI	40	0.564	0.346 0.663	63.4	ATRRTI	9	3.53.	-0.240 7.302	132.3	ASTRAG	.1	0.003	0.003 0.003	-	ARTTRI	5	0.249	-0.162 0.660	145.4
ASTRAG	39	0.031	0.019 0.043	91.2	ASTRAG	1	0.019	0.019 0.019	-	ATRCON	26	0.134	0.084 0.185	54.1	ASTRAG	20	0.091	0.044 0.139	78.7
ATRCON	59	0.459	0.372 0.547	51.8	ATRPAT	1	0.154	0.154 0.154	-	BARGRO	0	-	- -	-	ATRCON	29	0.154	0.065 0.244	146.2
BARGRO	0	-	- -	-	BARGRO	0	-	- -	-	CHRVIS	21	0.179	0.101 .258	58.5	BARGRO	0	-	- -	-
CHRVIS	6	0.134	0.023 0.246	69.0	CENPAU	1	0.013	0.013 0.013	-	CRUCIF	12	0.025	0.017 0.032	15.8	CHRGRE	5	0.037	0.026 0.048	4.5
CRUCIF	1	0.009	0.009 0.009	-	CHRNAU	21	1.923	-0.140 3.986	353.1	CRYGRM	0	-	- -	-	CHRVIS	29	0.218	0.137 0.298	59.1
CRYGRN	0	-	- -	-	CHRVIS	44	1.941	0.773 3.108	254.8	ERIGER	2	0.006	0.003 0.009	2.4	CHYGRE	2	0.157	-0.152 0.464	39.3

TABLE IV-14 (Cont.)

Shadscale					Riparian					Sagebrush/Greasewood					Juniper				
		Dry Matter (kg/4m^2)					Dry Matter (kg/4m^2)					Dry Matter (kg/4m^2)					Dry Matter (kg/4m^2)		
Species	Num Obs	Mean	90% C.I.	Sample Size	Species	Num Obs	Mean	90% C.I.	Sample Size	Species	Num Obs	Mean	90% C.I.	Sample Size	Species	Num Obs	Mean	90% C.I.	Sample Size
ERIGER	13	0.032	0.012 0.051	69.3	CIRSIU	1	0.008	0.008 0.008	-	ERIOGO	7	0.101	0.003 0.017	40.3	COMPAL	3	0.013	0.007 0.020	5.9
ERIOGO	3	0.035	0.022 0.047	4.9	CLELIG	1	0.018	0.018 0.018	-	EURLAN	6	0.057	0.012 0.103	43.8	CRUCIF	21	0.049	0.025 0.073	75.2
EUPHOR	2	0.013	0.007 0.019	2.0	CRYGRM	0	-	- -	-	GRASPI	19	0.168	0.077 0.260	81.6	CRYCRM	0	-	- -	-
EURLAN	4	0.024	-0.003 0.051	49.7	DISSPI	40	0.410	0.119 0.702	323.1	GUTSAR	24	0.040	0.021 0.059	78.9	DISSTR	11	0.134	-0.033 0.300	230.3
GUTSAR	36	0.079	0.045 0.113	107.2	EQUARV	6	0.050	-0.014 0.115	113.9	HILJAM	11	0.020	0.011 0.030	34.3	EPHIRR	4	0.057	-0.023 0.137	74.8
HALGLO	24	0.032	0.018 0.046	70.3	GUTSAR	3	8.680	-5.355 22.715	61.3	KOCVES	5	0.106	0.032 0.179	25.7	ERIGER	40	0.031	0.021 0.041	64.5
HILJAM	9	0.310	0.064 0.557	73.2	IVAAXI	11	0.013	0.005 0.022	60.4	LITTER	0	-	- -	-	ERIOGO	24	0.017	0.006 0.028	149.0
KOCVES	3	0.143	0.109 0.177	1.3	JUNBAL	1	0.024	0.024 0.024	-	OPUNTI	0	-	- -	-	EUPHOR	48	0.011	0.003 0.014	48.7
LITTER	0	-	- -	-	KOCSCO	4	0.674	0.138 1.210	24.1	ORYHYM	44	0.258	0.144 0.372	138.2	GUTSAR	55	0.082	0.042 0.122	211.7
OPUNTI	0	-	- -	-	LITTER	0	-	- -	-	SALKAL	34	1.706	0.463 2.949	288.7	HALGLO	1	0.118	0.118 0.118	-
ORYHYM	15	0.069	0.019 0.019	111.6	MELOFF	2	0.013	-0.002 0.028	12.8	SARVER	31	2.085	0.724 3.446	211.4	HILJAM	33	2.862	-1.720 7.444	1353.0
SALKAL	10	0.161	-0.007 0.330	143.7	MULASP	1	0.002	0.002 0.002	-	SITHYS	1	0.025	0.025 0.025	-	HYMSCA	4	0.036	-0.001 0.073	40.5
SARVER	8	0.431	0.032 0.930	87.4	OPUNTI	0	-	- -	-	SPHAER	5	0.025	-0.000 0.052	53.7	JUNOST	16	17.340	9.249 25.431	49.5
SITHYS	1	0.011	0.011 0.011	-	PHRCON	1	0.221	0.221 0.221	-	SPOCRY	1	0.338	0.338 0.338	-	LITTER	2	0.005	-0.010 0.020	86.6
SPHAER	5	0.024	0.003 0.046	42.9	POAFEN	4	0.025	0.003 0.048	30.7	STICOM	46	0.069	0.054 0.084	35.8	MULASP	1	0.059	0.059 0.059	-
STICOM	1	0.072	0.072 0.072	-	POPFRE	8	22.628	-0.380 45.636	103.5	TETSPI	7	0.222	-0.062 0.506	137.6	OPUNTI	0	-	- -	-

TABLE IV-14 (Cont.)

Shadscale

Dry Matter (kg/4m^2)

Species	Num Obs	Mean	90% C.I.	Sample Size
TETSPI	14	0.261	-0.009 0.531	209.6

Riparian

Dry Matter (kg/4m^2)

Species	Num Obs	Mean	90% C.I.	Sample Size
RHUTRI	1	0.004	0.004 0.004	-
SALEXI	11	0.409	-0.025 0.843	165.3
SALKAL	15	0.178	0.059 0.297	94.8
SARVER	8	6.700	0.512 12.859	85.4
SISALT	2	0.047	-0.084 0.178	79.4
SPHAER	2	0.003	0.001 0.004	3.5
SPOAIR	6	0.151	0.025 0.277	47.6
TAMPEN	14	13.838	2.932 24.743	121.4

Sagebrush/Greasewood

Dry Matter (kg/4m^2)

Species	Num Obs	Mean	90% C.I.	Sample Size

Juniper

Dry Matter (kg/4m^2)

Species	Num Obs	Mean	90% C.I.	Sample Size
ORYHYM	53	0.110 0.	0.041 0.180	334.9
PHLHOO	5	0.006	-0.001 0.013	68.4
POAFEN	1	0.002	0.002 0.002	-
POASAN	5	0.010	-0.003 0.023	93.3
SALKAL	1	0.001	0.001 0.001	-
SENECO	2	0.249	0.188 0.310	0.6
SITHYS	3	0.031	0.005 0.057	16.0
SOLRIG	8	0.042	0.025 0.060	17.4
SPHAER	1	0.007	0.007 0.007	-
STICOM	1	0.013	0.013 0.013	-
TETSPI	1	0.117	0.117 0.117	-

TABLE IV-15

PRODUCTION OF ANNUAL GRASSES AND FORBS IN JUNE 1975 ON TRACTS Ua AND Ub IN EACH OF FOUR VEGETATION TYPES.*

Vegetation Type	Production of herbage, g/m^2		
	Forbs	Grasses	Total
1. Sagebrush/Greasewood	3.33	47.77	51.10
2. Juniper	1.22	7.58	8.80
3. Shadscale	51.20	173.10	224.30
4. Riparian	56.71	533.25	589.96

*Data are the mean production from 100 one-half meter square plots in each vegetation type.

Some annual invader species, such as downy brome, Russian thistle, and the poisonous range weed, halogeton, grew abundantly in spring and summer 1975. These annual weeds grew primarily in disturbed areas and along roads. The Russian thistle and halogeton remained green through the summer and by September began to show signs of reddish color and approaching seed maturity.

Productivity in fall 1975 was different for each of the vegetation types (Tables IV-16, IV-17, IV-18, and IV-19). Data were reported on the basis of 100 plots, even though various plant species did not occur in all of the plots. The reason for computing the data in this manner was to provide an estimate of the general productivity of the entire area, bare ground excluded. In order of increasing productivity the juniper type produced 278.2 g per 4-m^2 plot (dry weight); the sagebrush/greasewood, 428.9 g; the shadscale type, 608.3 g; and the riparian, 2,908.80. Converted to kg/ha, these figures are as follows:

Juniper	695.9 kg/ha	(621.1 lb/ac)
Sagebrush/greasewood	1,072.5 kg/ha	(957.3 lb/ac)
Shadscale	1,520.7 kg/ha	(1,357.3 lb/ac)
Riparian	7,272.0 kg/ha	(6,490.6 lb/ac)

This productivity represents the current year's growth of the perennial forbs, grasses, trees, and shrubs on an area-wide basis. It is assumed that the five sampling sites for each vegetation type and the 20 randomly chosen 4-m^2 plots within each of the five sites are representative of the vegetation type.

d. Conclusions

The growing season of 1975 was extremely favorable for vegetation production. Many of the shrub species sampled had individual stem growth almost double the length generally observed in late September 1974. Contrasted with extremely dry years, perennial plant productivity in 1975 would be considered high compared with any long-term average.

The data reported in Tables IV-16, IV-17, IV-18, and IV-19 cannot be compared directly with production data reported for fall 1974 because a different basis for calculation was used. For the 1974 data only the actual number of plots in which a species occurred was used as a basis. Both methods of analysis are correct. The actual plot basis estimates production as it occurs on a clumped, or aggregated, plant grouping basis, whereas the total plot basis (100 plots) estimates productivity for the entire area, including bare area.

TABLE IV-16

FALL 1975 PRODUCTION BY SPECIES SAGEBRUSH/GREASEWOOD, VEGETATION TYPE

Species	Yield, g/plot	No. Obs.	No. Samples Required 1)
ARTSPI	6.49	7	42.3
ARTTRI	66.25	64	37.8
ASTRAG	.63	1	-
ATRARG	1.88	1	-
ATRCON	56.04	94	24.0
ATRPOW	.75	1	-
CHRGRE	21.73	13	73.8
ERIEFF	10.00	15	81.5
ERIENG	.75	24	36.0
ERIOGO	.38	3	4.8
EURLAN	1.96	5	36.4
GRASPI	21.67	3	17.3
GUTSAR	5.96	37	505.5
HALGLO	10.00	5	216.4
HILJAM	16.88	9	41.6
OPUNTI	7.06	14	52.6
ORYHYM	6.99	28	823.1
SARVER	23.23	18	71.1
SITHYS	1.75	2	15.9
SPHCOC	1.19	14	36.9
SPHPAR	.50	2	21.6
SPOAIR	20.63	2	35.1
SPOCRY	6.17	8	13.5
STALIT	32.83	98	95.3
STICOM	3.49	10	104.8
SUASUF	4.50	5	74.9
TETNUT	74.69	2	1.7
TETSPI	24.77	15	73.6

Average Yield/100 plots
all species = 428.9 g

1) No. samples required to estimate within 25% the true mean with a 90% level of statistical confidence.

TABLE IV-17

FALL 1975 PRODUCTION BY SPECIES
JUNIPER, VEGETATION TYPE

Species	Yield, gms/plot	No. Obs.	No. Samples Required 1/
ARTNOV	12.06	42	66.2
ARTTRI	7.43	18	59.7
ASTRAG	33.91	6	48.4
ARTCON	3.39	19	53.6
BOUGRA	.30	1	-
CHRGRE	2.34	6	122.7
CHRVIS	9.61	9	35.5
CRUCIF	.06	6	15.2
CRYPTA	.99	33	21.7
EPHVIR	1.75	5	42.8
ERICIR	.59	7	23.8
ERIMIC	.83	23	131.7
ERIOGO	.40	10	21.2
ERIOVA	.30	10	24.0
ERIVIS	.26	4	43.7
EUPFEN	.68	22	31.0
EUPROB	.84	7	15.2
GRASPI	3.60	1	-
BUTSAR	.74	51	53.0
HALGLO	2.41	2	84.9
HEDBOR	5.04	5	27.5
HILJAM	14.92	12	218.3
JUNOST	102.83	56	77.3
KOCAME	1.80	1	-
LEPPUN	.22	3	7.5
OPUPOL	2.40	1	206.3
ORYHYM	1.10	18	-
PETPUM	2.37	16	63.4
PHLHOO	1.13	13	76.2
PINEDU	60.62	2	82.3
POASEC	6.85	6	22.5
RANTES	.21	2	15.9
SITHYS	.42	2	15.9
STALIT	24.27	68	189.7
STICOM	.51	20	54.2

Average Yield/100 plots, all species = 278.18 gms

1/ No. of samples required to estimate within 25% of the true mean with a 90% level of statistical confidence.

TABLE IV-18

FALL 1975 PRODUCTION BY SPECIES
SHADSCALE, VEGETATION TYPE

Species	Yield, g/plot	No. Obs.	No. Samples Required 1/
AMBSPI	2.50	1	-
ARTNOV	42.44	22	69.6
ARTSPI	34.63	5	71.7
ARTTRI	69.35	47	29.6
ASTRAG	.76	5	73.6
ATRCON	12.74	38	25.7
CHRGRE	34.16	38	57.5
CHRNAU	66.10	2	-
EPHUIR	3.75	2	86.6
ERIENG	1.08	6	40.3
ERIOGO	2.34	13	28.5
EURLAN	6.91	8	34.1
GRASPI	58.20	29	33.6
GUTSAR	7.35	14	55.2
HILJAM	11.60	10	27.5
HYMENO	1.88	2	9.6
LEPMON	12.50	3	-
OPUNTI	2.75	2	-
ORYHYM	16.71	49	36.5
SARVER	61.89	40	69.0
SITHYS	3.88	6	30.6
SPHCOC	4.63	4	94.3
SPOCRY	3.96	3	26.0
STALIT	104.54	99	45.0
STICOM	24.42	39	47.0
SUAEDA	8.54	3	1.5
TETSPI	17.71	6	27.2

Average Yield/100 plots
all species = 608.3 g

1/ No. samples required to estimate within 25% the true mean with a 90% level of statistical confidence.

TABLE IV-19

FALL 1975 PRODUCTION BY SPECIES
RIPARIAN, VEGETATION TYPE

Species	Yield, g/plot	No. Obs.	No. Samples Required 1/
AGRSMI	25.84	24	278.0
AMBPSI	4.76	5	120.0
ARTLUD	.75	1	-
ARTTRI	22.25	6	30.2
ATRCAN	33.79	3	73.8
ATRCON	3.00	1	-
ATRPAT	4.26	21	27.6
ATRPOW	2.50	1	-
CHRNAU	57.23	27	175.7
CHRVIS	56.95	46	76.8
CIRSIU	10.63	2	-
CLELIG	7.75	2	-
CLESER	5.00	2	-
COMPAL	18.19	11	67.3
DESSOP	-	1	-
DIFFDI	25.00	1	-
DISSPI	35.14	48	74.6
EMLORF	.50	1	-
EQUARV	73.23	6	107.0
ERIENG	.88	3	22.1
GRISQU	.75	1	-
GUTSAR	.50	1	-
JUNBAL	4.40	5	32.7
MELOFF	15.75	25	53.3
MUHASP	262.50	2	-
OPUNTI	.75	1	-
PHRCON	24.00	3	31.0
POAPRA	73.10	5	34.0
POPFRE	522.47	31	27.7
RHUTRI	.38	1	-
ROSWOO	8.75	1	-
SALEXI	118.13	13	39.1
SALKAL	23.00	16	78.2
SARVER	175.19	12	93.2
SENELI	23.70	1	-
SPOAIR	33.75	3	61.7
SSTALI	400.00	1	-
STALIT	691.53	99	8.3
TAMPEN	110.00	13	29.4
TAROFF	32.50	1	-

Average Yield/100 plots
all species = 2908.8 g

1/ No. samples required to estimate within 25% the true mean with a 90% level of statistical confidence.

e. Work Scheduled

Productivity assessment of each vegetation type will be made in the spring of 1976 to determine production of annual species. Data from all the four sampling periods will be pooled to document primary production and make a determination of site productivity potential.

5. ANCILLARY ENVIRONMENTAL FACTORS AND OBSERVATIONS

a. Root Growth

Root growth was studied to determine existing water and soil conditions and to provide information regarding the adaptations of vegetation that could survive on the tracts. Methods appropriate to each measurement were used (refer to Partial Exploration Plan).

A key factor in the existence of vegetation in harsh environments such as the tracts is the various types of root systems that allow their adaptation to shallow or deep soils and drought conditions. Soil depths on the tracts range from near 0 cm on exposed and fracture bedrock to deep alluvium (10 m to 15m (33 ft to 49 ft)) in the canyon bottoms and small drainages. The shrubs on the tracts have root systems to meet these soil conditions. Some typical root patterns were observed in studies of roots during summer 1975.

Spiny horsebrush (Tetrademia spinescens) has a shallow root system that seldom penetrates more than 15 cm (6 in.) (Figure IV-7). The main roots of this species grow laterally, often producing shoots that become small plants adjacent to the main one. The plant loses small leaves in midsummer at a time when soil moisture in the top 15 cm to 25 cm (6 in. to 10 in.) is depleted.

Big sagebrush (Artemisia tridentata), shadscale (Atriplex confertifolia), and rabbitbrush (Chrysothamnus nauseosus) have a root system adapted to both shallow and deep penetration of the soil (Figure IV-8, IV-9, and IV-10) that enables them to exist on sites of moderately shallow to deep soils. This is often called "two-layered" because it has a shallow system of finely divided roots and a deep-penetrating taproot system that can extend into the fractured parent material where soil moisture may persist into the summer months. The root systems of other closely-related species are variations of this system: saltbush, Atriplex cuneata has a predominantly shallow root system compared with that of big sagebrush, and rabbitbrush, Chrysothamnus linifolius has a deeply spreading system adapted to alluvial soils and root sprouts to produce a colony of plants.

The root system of greasewood (Sarcobatus vermiculatus) is predominantly deep, often extending greater than 2m (6.5 ft), with a tap root system that enables it to grow in deep, coarse, alluvial soils (Figure IV-11). Greasewood occurs in small clumps, often to the exclusion of other species. The deep-rooted habit must be considered in transplanting it as a seedling, not only in digging up a sufficient amount of the root, but also in placing the seedling in a site with deep soil.

The root system of Utah juniper (Juniperus osteosperma) was not studied on the tracts, but previous observations and published literature indicate that this evergreen tree has a relatively shallow root system sometimes no deeper than 1 m (3 ft) and extending laterally more than two times the diameter of the canopy. It uses the soil moisture supply in the vicinity of the tree and allows only a few ephemeral annual plants such as lambs' quarters (Chenopodium album) or a deep-rooted perennial forb like white-flowered pepper grass (Lepidium montanum) to grow under the juniper canopy. Sagebrush and perennial grasses are not found in association with juniper; and they only occur as fingers, or intrusions, into a juniper stand.

Annual grasses such as Bromus tectorum have shallow root systems that dominate the top 15 cm to 20 cm (6 in. to 8 in.) of soil. The roots are profuse and finely divided but live plants do not persist on the tracts beyond late spring.

b. Vegetation in Relation to Soil Salinity

To identify some general relationships between on-site salinity levels and vegetation occurrence, soils were sampled in the vicinity of Evacuation Creek. Soil samples from eight locations adjacent to and on the various levels above the creek were obtained and returned to the laboratory for evaluation. The two most saline samples were obtained a few centimeters above the level flowing water of the creek in a sandy bank that supported a stand of saltgrass (Distichlis stricta) and on a rocky shelf 1 m(3 ft) above the water level in a dry seep area between strata of the nahcolite formation (Table IV-20). Highly saline soils were found in salt accumulation areas 45 cm (18 in.) above the stream and in a continuous seep area within the nahcolite strata. In these areas, saltgrass, Tamarix pentandra, and sedges (Carex spp.) were

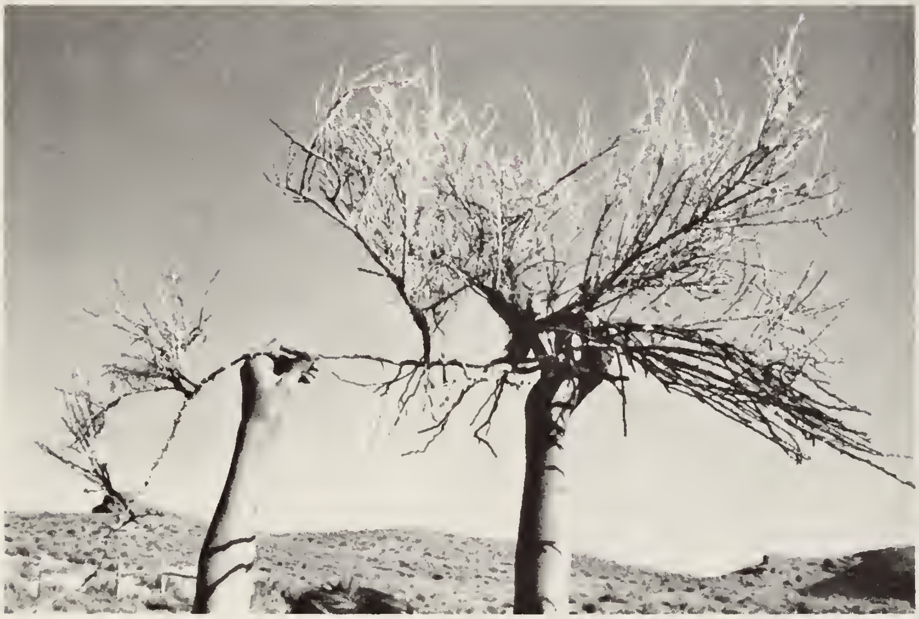


FIGURE IV-7 ROOT SYSTEM OF SPINY HORSE BRUSH.

Root system of spiney horsebrush (Tetradymia spinescens) showing the shallow spreading nature of this species. Note the stems sprouting from these shallow roots.

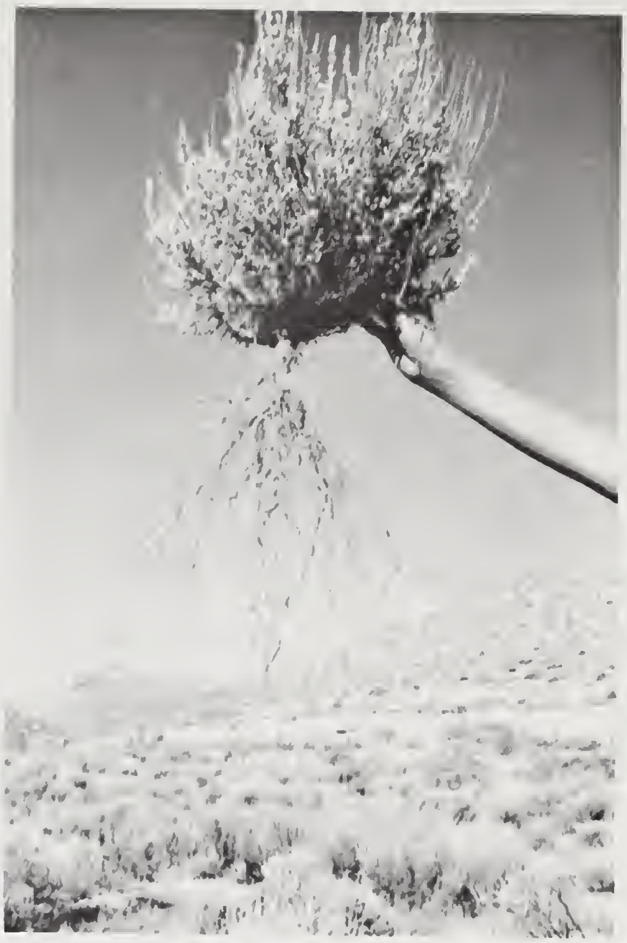


FIGURE IV-8 ROOT SYSTEM OF BIG SAGEBRUSH.

Root system of big sagebrush (Artemisia tridentata) showing roots for shallow and deep penetration of the soil.

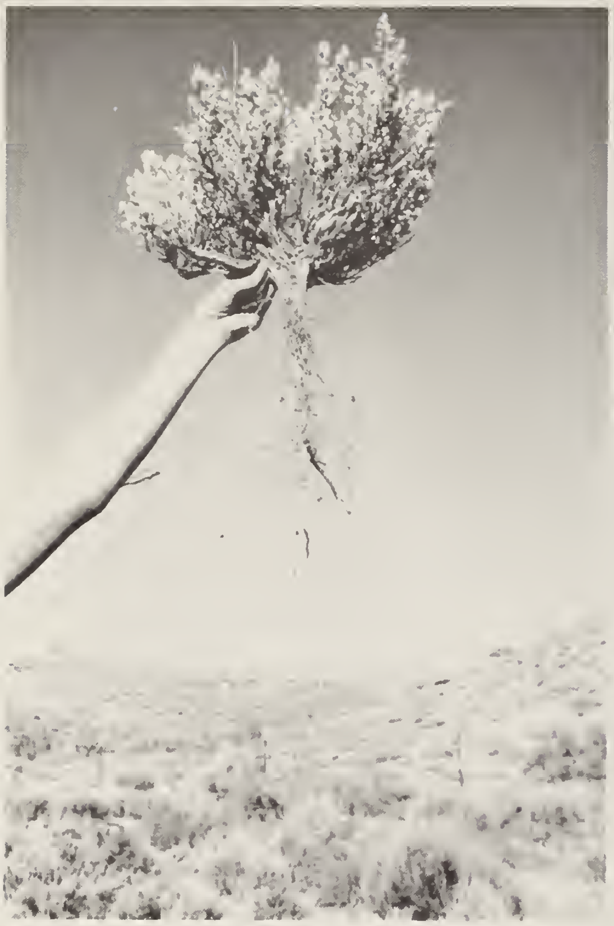


FIGURE IV-9 ROOT SYSTEM OF SHADSCALE.

Root system of shadscale (Atriplex confertifolia). This species has roots adapted for shallow and deep moisture extraction.

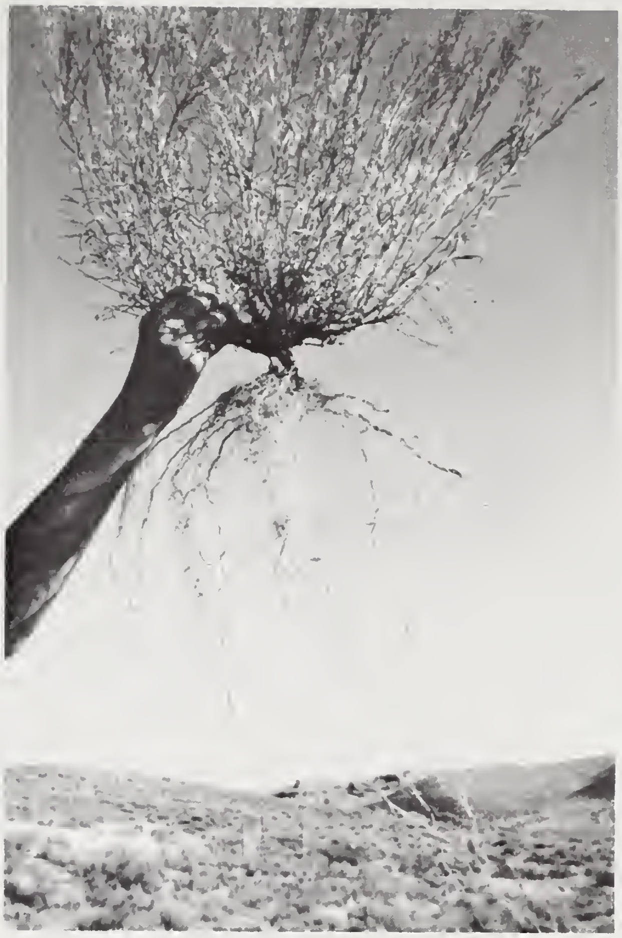


FIGURE IV-10 ROOT SYSTEM OF RABBITBRUSH.

Rabbitbrush (*Chrysothamnus nauseosus*) root system. Multiple roots of this species not only grow deep into the soil but also in the upper layers of the profile.

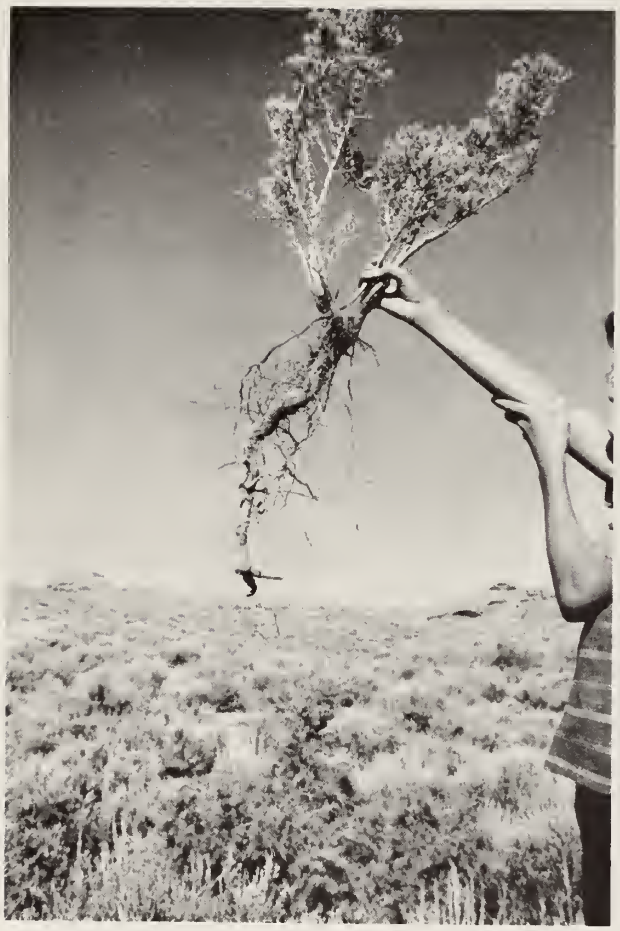


FIGURE IV-11 ROOT SYSTEM OF GREASEWOOD.

Greasewood (Sarcobatus vermiculatus) root system showing the predominant tap root with finely divided side branches for deep soil penetration.

TABLE IV-20

SALINITY VALUES - FOR SOILS NEAR EVACUATION CREEK AND ASSOCIATED VEGETATION

No.	Vegetation	Location	ph Sat. Paste	ph Sat. Extract	Ec mmhos/cm	Salinity Parts/thousand
1.	Distichlis stricta	wet soil, streamside 15 cm up bank	8.9	8.7	>50	>40
2.	Distichlis stricta and Tamarix pentandra	crack in rocky cliff above creek	9.4	9.0	>50	34
3.	Distichlis stricta	45 cm up stream bank	8.6	8.4	44	30
4.	Tamarix pentandra (nearby)	salt seep area in cliff	9.5	9.5	41	27
5.	Distichlis stricta	shelf above stream, wet soil surrounded by salt crust	8.7	8.6	6.7	4
6.	Distichlis stricta, Chrysothamnus nauseosus, Sarcobatus vermiculatus	terrace 1 meter above stream	8.3	8.2	3.7	2
7.	Sarcobatus vermiculatus Bromus tectorum	terrace 2 meters above stream side	9.3	8.0	1.1	<1
8.	Bromus tectorum	terrace 3 meters above stream side	8.8	7.8	.4	<1

found growing, although poorly. Intermediate salinity of 6.7 Ec (electrical conductivity) was measured in moist clay taken from a seep shelf above the streambed, where the only vegetation was saltgrass.

Progressively lower salinity levels were observed from terraces that were 1 m, 2 m, and 3 m (3 ft, 6.5 ft, and 10 ft) higher than the streambed. Salinity levels (as measured by electrical conductivity) were 3.7 mmhos/cm, 1.1 mmhos/cm, and 0.4 mmhos/cm, respectively. The vegetation observed ranged from saltgrass, rabbitbrush (Chrysothamnus nauseosus), and greasewood at the 1-m (3-ft) terrace to cheatgrass (Bromus tectorum) at the 3-m (10-ft) terrace.

These measures of salinity indicate a wide range of salt concentrations within a small area around the highly saline Evacuation Creek. Vegetation growing in soils with such high salinity levels indicates a high tolerance for salt. Capillary rise from the water level or seepage from within the nahcolite formation tends to accumulate the salts to high concentrations. Even so, certain plants are adapted to grow under such conditions. Information concerning these plant tolerances and salinity levels will be useful in developing a revegetation technology for the processed shale. Data on soil moisture will be collected by on-site personnel in 1976.

c. Work Scheduled

Both the root growth study and vegetation/salinity study were carried out as ancillary observations of the vegetation program and are complete in their analysis. These studies will not be run for the second year of the baseline program.

B. TERRESTRIAL VERTEBRATES

This portion of the baseline program is presented in three parts: 1) a general determination of vertebrate species, population dynamics of these species, and interactions of these species with the ecosystem, 2) special studies of selected vertebrate taxa for economic reasons or as indicator species, and 3) a brief discussion of the continuation of the baseline program for the second year.

The terrestrial vertebrate program was designed to comply with the lease stipulations outlined in the Federal Register concerning baseline data. The methods used to develop baseline information concerning terrestrial vertebrates were by necessity a compromise. A sampling program consisting of the best techniques to sample each group of animals, with sufficient application to cover the variability encountered, was designed that met the requirements of the lease stipulations and yet maintained a reasonable perspective as to the size and scope of the program.

The specific objectives of the terrestrial vertebrate sampling program are as follows:

(1) To list all terrestrial vertebrate species

(2) To determine distribution of each species

(3) To estimate the population density of each species

(4) To record the migratory activity of migrant species

(5) To complete a comprehensive description of the relationships between terrestrial vertebrates and other components of the ecosystem

Three types of sampling programs were developed to meet the stated objectives:

(1) a scheduled program in which specified areas were sampled at specific times to meet the second, third, and fourth objectives

(2) special studies of some economically important vertebrates were conducted to augment the scheduled programs

(3) a non-scheduled opportunistic (e.g., when fauna are most active) sampling and observation program were conducted to meet the first and fifth objectives

1. GENERAL SAMPLING

a. Objectives

The general sampling program was undertaken to determine the distribution of vertebrate species, to estimate the population densities, and to record the activity of migratory species.

b. Methodology

The scheduled sampling program was conducted at 12 sampling sites (Figure IV-6). These sites were chosen because they represented the four major vegetation types in the project area and the area proposed for depositing processed shale.

There are four primary sampling sites on the tracts, one in each major vegetation type. As the most important sites, they are sampled more intensively than the others. The sites were designated primary greasewood (WG-1), primary juniper (WJ-1), primary shadscale (WS-1), and primary riparian (WR-1).

To augment data from the primary sampling sites, three secondary sampling sites were established in similar vegetation at different locations within the tracts. The secondary sites were designated secondary greasewood (WG-2), secondary juniper (WJ-2), and secondary shadscale (WS-2). The lack of sufficient accessible areas of riparian vegetation precluded establishing a secondary riparian site.

Five off-tract sites were established for sampling areas adjacent to the tracts. The off-tract sites were designated off-tract greasewood (WG-3), off-tract juniper (WJ-3), off-tract shadscale (WS-3), off-tract riparian (WR-2), and riparian greasewood (WR-3).

Two major sampling techniques were used to determine the numbers and kinds of terrestrial vertebrates on the sites. Flushing transects were used to sample diurnal mammals, birds, and amphibians and reptiles; and live-trapping was used to sample nocturnal rodents. A 1.0-km (0.6-mi) flushing transect was marked out on each primary sampling site except on the one in riparian vegetation. A 0.5-km (0.3-mi) transect was positioned to obtain a representative sample of the vertebrates within the vegetation type. Biologists walked the transects and recorded the animal species seen and the distance in meters of each animal from the transect line at first sighting (Table IV-21).

TABLE IV-21

SCHEDULED SAMPLING PROGRAM OF KILOMETERS OF FLUSHING TRANSECTS WALKED AND NUMBER OF TRAP NIGHTS USED FOR TERRESTRIAL VERTEBRATES ON 12 SAMPLING SITES FROM DECEMBER, 1974 THROUGH OCTOBER, 1975

Month	Sampling Method	Sampling Sites												Total
		WS1	WJ1	WG1	WR1	WS2	WJ2	WG2	WR2	WS3	WJ3	WG3	WR3	
Dec.	Mammal Transects	5	5	5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	37.5
	Bird Transects	5	5	5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	37.5
	R & A* Transects													
	Trap Transects													
	Trap Grids													
Feb.	Mammal Transects	5	5	5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	37.5
	Bird Transects	5	5	5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	37.5
	R & A* Transects													
	Trap Transects													
	Trap Grids													
April	Mammal Transects	5	5	5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	37.5
	Bird Transects	5	5	5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	37.5
	R & A* Transects													
	Trap Transects	120	96	120	120	120	120	120	120	48	120	120	48	1272
	Trap Grids													
June	Mammal Transects	5	5	5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	37.5
	Bird Transects	5	5	5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	37.5
	R & A* Transects	3	5	5	2.5	1.5	2.5	2.5	2.5	1.5	2.5	2.5	1.5	32.5
	Trap Transects	120	120	120	120	120	96	120	120	120	102	96	120	1392
	Trap Grids													
Aug.	Mammal Transects	5	5	5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	37.5
	Bird Transects	5	5	5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	37.5
	R & A* Transects	5	5	5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	37.5
	Trap Transects					120	120	120	120	120	120	120	120	960
	Trap Grids	720	720	702	360									1860
Oct.	Mammal Transects	5	5	5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	37.5
	Bird Transects	5	5	5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	37.5
	R & A* Transects		4	4	2		2.5	2	2		2	2.5		21
	Trap Transects		24	24	120		120	24	120		24	120		768
	Trap Grids													

*Reptile and Amphibian

Variation for the statistical analysis was generated by daily variation in the number of animals seen along the transects. Confidence intervals were given for species dense enough to make such a probability statement meaningful. The statements regarding the reliability of the density figures apply to the precision of the estimate at the time and place the data were collected. The Partial Exploration Plan discussed in detail the field methods and the mathematical and statistical basis for the approach used in the analysis of flushing-transect data.

A rodent live-trapping grid was established at each primary sampling site. The grid on the greasewood, juniper, and shadscale sites consisted of 12 rows of trap stations and 12 stations per row (144 trap stations). The grid at the riparian site consisted of 6 rows of trap stations and 12 trap stations per row (72 trap stations). The following information was recorded on field-data sheets for each capture: (1) date, (2) sampling site, (3) sampling day, (4) species, (5) sex, (6) age, (7) animal condition, (8) animal identification number, (9) trap number, and (10) capture number.

The Jennrich and Turner (1969) method of determining home range was used to analyze the trapping data. Density estimates were made with the Schnabel (1938) technique, as presented by Overton (1965). Robert Anderson (Balph 1973) discussed the details of the type of analysis used.

A rodent live-trapping transect was established at each of the secondary and off-tract sampling sites. The transect consisted of 2 parallel lines of 12 trap stations each, with 15 m (49 ft) between the lines and 15 m (49 ft) between the trap stations, with the trapping transects straddling the flushing transects. The data collected were presented as the number of captures per 100 trap nights and were meant to be an index to density rather than an estimate of density. The scheduled sampling program is discussed in detail in the Partial Exploration Program.

c. Mammals

Summary of Results

From December 1974 through October 1975, 25 species of mammals other than domestic livestock were observed on or within 1.6 km (1 mi) of the tracts (Table IV-22). In addition, an unidentified species of weasel was recorded in August; and unidentified bats, perhaps representing several species,

TABLE IV-22

MAMMALIAN SPECIES LIST FROM OBSERVATIONS ON OR WITHIN 1.6 KM (1 MILE) OF UTAH OIL SHALE TRACTS, DECEMBER 1974 THROUGH OCTOBER 1975.

X = mammal observed, G = greasewood, J = juniper, S = shadscale, R = riparian.

Mammal (Order/Species)	Date/Vegetation Type																							
	December 1974				February 1975				April 1975				June 1975				August 1975				October 1975			
	G	J	S	R	G	J	S	R	G	J	S	R	G	J	S	R	G	J	S	R	G	J	S	R
Chiroptera																								
Western Pipistrel	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bat (unidentified species)																								
Carnivora																								
Raccoon	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Weasel (unidentified species)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	-	-	-	-	-	-
Striped Skunk	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-
Badger	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X
Coyote	-	-	X	-	-	-	-	-	-	-	X	X	X	-	-	X	-	-	-	-	-	X	-	X
Mountain Lion	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-
Rodentia																								
Yellowbelly Marmot	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-
Whitetail Antelope Squirrel	X	X	X	-	X	X	X	-	X	X	X	-	X	X	X	-	X	X	X	-	X	-	X	-
Golden-mantled Squirrel	-	-	-	-	-	X	X	-	X	X	-	-	X	X	-	X	X	X	X	X	X	X	X	X
Least Chipmunk	-	-	-	-	-	-	-	-	X	X	-	-	-	X	X	-	X	-	-	-	-	-	-	-
Colorado Chipmunk	-	-	-	-	-	X	-	-	-	X	-	-	X	X	-	X	X	X	-	-	-	X	-	X
Whitetail Prairie Dog	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	X	-	X	-	-	-	X	-
Apache Pocket Mouse	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	-	X	X	X	X	X	X	-	X
Ord Kangaroo Rat	-	-	-	-	-	-	-	-	X	-	X	-	X	-	X	X	X	-	X	X	X	-	-	-
Beaver	-	-	-	X	-	-	-	-	-	-	-	X	-	-	-	X	-	-	-	-	-	-	-	-
Western Harvest Mouse	-	-	-	-	-	-	-	-	X	X	-	-	X	-	-	-	-	-	-	-	-	-	-	-
Deer Mouse	X	X	X	X	X	-	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	-	X
Brush Mouse	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-
Pinyon Mouse	-	-	-	-	-	-	-	-	-	X	-	-	-	X	-	-	-	X	-	-	-	X	-	-
Desert Woodrat	-	X	-	-	X	X	-	-	-	X	-	-	X	X	-	-	X	X	X	X	X	X	-	-
Bushytail Woodrat	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	-	-	-	-
Muskrat	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Porcupine	-	-	-	X	-	-	-	X	-	-	-	X	-	-	-	X	-	-	-	-	-	X	-	X
Lagomorpha																								
Desert Cottontail	X	-	X	X	X	X	X	-	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Artiodactyla																								
Mule Deer	-	-	X	X	X	X	-	-	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Domestic Sheep	X	X	X	-	-	-	-	X	X	X	X	X	-	-	X	X	-	-	-	-	-	-	-	-
Domestic Cattle	-	-	-	X	-	-	-	-	-	-	-	-	-	-	X	X	-	-	X	X	-	-	-	X

TABLE IV-23

MAMMAL DENSITIES AS DETERMINED BY FLUSHING TRANSECTS ON 12 SITES IN FOUR VEGETATION TYPE

"Blanks" Indicate Insufficient Data for Meaningful Determination

		Date																	
		December 1974			February 1975			April 1975			June 1975			August 1975			October 1975		
Sampling Site	Mammal (Species)	Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval
Primary Greasewood	Whitetail Antelope Squirrel	1	0.03		--	--		--	--		2	0.20		--	--		--	--	
	Golden-Mantled Squirrel	-	--		--	--		--	--		1	0.01		--	--		--	--	
	Desert Cottontail	-	--		--	--		--	--		2	0.03		2	0.20		1	0.04	
	Total	1	0.03		0	0.00		0	0.00		5	0.24		2	0.20		1	0.04	
Secondary Greasewood	Whitetail Antelope Squirrel	-	--		--	--		1	0.40		17	1.70	0.64-2.76	--	--		8	0.50	
	Golden-Mantled Squirrel	-	--		--	--		--	--		--	--		1	0.07		--	--	
	Least Chipmunk	-	--		--	--		--	--		--	--		1	0.13		--	--	
	Desert Cottontail	-	--		--	--		--	--		2	0.20		4	0.40		2	0.10	
	Total	0	0.00		0	0.00		1	0.40		19	1.90		6	0.60		10	0.60	
Off-Tract Greasewood	Whitetail Antelope Squirrel	-	--		--	--		--	--		1	0.10		--	--		2	0.08	
	Golden-Mantled Squirrel	-	--		--	--		--	--		1	0.40		--	--		--	--	
	Desert Cottontail	3	0.20		0	0.00		2	0.10		2	0.13		9	1.60		18	3.13	1.51-4.76
	Unidentified, Chiroptera	-	--		--	--		--	--		1	0.04		7	2.00		--	--	
	Total	3	0.20		0	0.00		2	0.10		5	0.67		16	3.60		20	3.21	
Primary Juniper	Desert Cottontail	-	--		--	--		--	--		3	0.20		2	0.10		11	1.40	0.92-1.88
	Unidentified, Chiroptera	-	--		--	--		--	--		--	--		1	0.20		--	--	
	Total	0	0.00		0	0.00		0	0.00		3	0.20		3	0.30		11	1.40	
Secondary Juniper	Colorado Chipmunk	-	--		--	--		--	--		--	--		1	0.40		--	--	
	Desert Woodrat	1	0.08		--	--		--	--		--	--		2	0.20		--	--	
	Desert Cottontail	-	--		--	--		--	--		--	--		4	0.40		10	1.02	0.23-1.82
	Unidentified, Chiroptera	-	--		--	--		--	--		--	--		--	--		1	0.40	
	Total	1	0.08		0	0.00		0	0.00		0	0.00		7	1.00		11	1.42	
Off-Tract Juniper	Golden-Mantled Squirrel	-	--		--	--		--	--		5	0.40		--	--		--	--	
	Colorado Chipmunk	-	--		--	--		--	--		1	0.08		--	--		2	0.27	
	Desert Cottontail	-	--		--	--		--	--		1	0.40		6	2.40		3	0.12	

TABLE IV-23 (cont.)

		Date																	
		December 1974			February 1975			April 1975			June 1975			August 1975			October 1975		
Sampling Site	Mammal (Species)	Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval
Off-Tract Juniper (continued)	Mule Deer	--	--		--	--		--	--		1	0.01		--	--		--	--	
	Unidentified, Sciuridae	--	--		--	--		--	--		--	--		--	--		1	0.03	
	Total	0	0.00		0	0.00		0	0.00		8	0.89		6	2.40		6	0.42	
Primary Shadscale	Whitetail Antelope Squirrel	--	--		2	0.03		--	--		1	0.07		--	--		3	0.10	
	Desert Cottontail	2	0.04		14	0.50	0.50-0.50	2	0.05		13	0.40	0.06-0.74	11	0.67	0.36-0.98	6	0.80	
	Total	2	0.04		16	0.53		2	0.05		14	0.47		11	0.67		9	0.90	
Secondary Shadscale	Desert Cottontail	3	0.40		3	0.13		--	--		1	0.04		3	0.13		4	1.60	
	Domestic Sheep	--	--		--	--		50	0.25		--	--		--	--		--	--	
	Total	3	0.40		3	0.13		50	0.25		1	0.04		3	0.13		4	1.60	
Off-Tract Shadscale	Whitetail Antelope Squirrel	--	--		--	--		--	--		--	--		2	0.20		1	0.13	
	Desert Cottontail	--	--		--	--		--	--		2	0.16		4	0.11		--	--	
	Total	0	0.00		0	0.00		0	0.00		2	0.16		6	0.31		1	0.13	
Primary Riparian	Beaver	--	--		--	--		--	--		1	0.07		1	0.05		--	--	
	Porcupine	--	--		--	--		1	0.07		1	0.04		--	--		--	--	
	Desert Cottontail	--	--		--	--		--	--		2	0.80		--	--		--	--	
	Mule Deer	--	--		--	--		--	--		1	0.20		4	0.13		13	0.60	0-1.38
	Domestic Sheep	--	--		9	0.09		--	--		--	--		--	--		--	--	
	Domestic Cattle	--	--		--	--		--	--		--	--		33	6.40		31	1.20	
	Unidentified, Chiroptera	--	--		--	--		--	--		4	0.27		--	--		--	--	
	Total	0	0.00		9	0.09		1	0.07		9	1.38		38	6.58		44	1.80	
Off-Tract Riparian	Porcupine	--	--		--	--		1	0.10		--	--		--	--		--	--	
	Desert Cottontail	3	0.40		--	--		4	0.30		3	0.20		3	0.40		1	0.13	
	Mule Deer	--	--		--	--		--	--		--	--		2	0.10		2	0.40	
	Domestic Cattle	--	--		--	--		--	--		--	--		--	--		24	2.80	
	Unidentified, Chiroptera	--	--		--	--		--	--		--	--		6	2.00		--	--	
	Total	3	0.40		0	0.00		5	0.90		3	0.20		11	2.50		27	3.33	

TABLE IV-23 (cont.)

Sampling Site	Mammal (Species)	December 1974			February 1975			April 1975			June 1975			August 1975			October 1975		
		Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence	Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval
Riparian Greasewood	Golden-Mantled Squirrel	--	--		--	--		--	--		1	0.07		1	0.10		--	--	
	Colorado Chipmunk	--	--		--	--		--	--		1	0.08		--	--		--	--	
	Desert Cottontail	1	0.40		--	--		--	--		9	1.20		3	0.16		23	3.27	0.73-5.80
	Unidentified, Chiroptera	--	--		--	--		--	--		--	--		2	0.80		--	--	
	Total	1	0.40		0	0.00		0	0.00		11	1.35		6	1.06		23	3.27	

were sighted in June, August, and October. Fewer native (non-domestic) species were seen in winter (11 species and 8 species in December and February, respectively) than in other sampling periods, when the number of verified species ranged from 14 to 17. The number of species varied little from one major vegetation type to another: 15 verified species were seen in greasewood; 14, in juniper; 14, in shadscale; and 16, in riparian.

Population densities of native diurnal mammals, estimated from data collected on mammal-transect walks, were low during December, February, and April, ranging from 0.00 to 0.90 mammals per hectare (ha) (Table IV-23). Shadscale appeared to be the least populated vegetation type, with mammal population densities ranging from 0.00 to 0.08 per ha. Diurnal-mammal population densities increased from April to June and again from June to August, in all four major vegetation types. Densities in October were fairly similar to those in August. During the summer and fall, estimated numbers per ha of diurnal mammals were generally highest on the greasewood and riparian sampling sites (up to 3.60 in greasewood and 3.27 in riparian) and lowest on the shadscale sites (up to 1.60). Although livestock were sometimes seen on transect walks, sampling was timed to avoid them as much as possible because sheep or cattle on a transect tended to keep native mammals away.

The only native diurnal mammal seen regularly in winter and spring was the desert cottontail, which was found in all four major vegetation types. Their estimated population densities on the sampling sites range up to 0.80 per ha from December through April (Table IV-23). The number of desert cottontails appeared to increase markedly during summer and fall, with estimated densities ranging up to 1.40 per ha in June, 1.60 per ha in August, and 3.27 per ha in October. Other mammals commonly seen during the summer were whitetail antelope squirrels in greasewood (up to 1.70 per ha in June) and unidentified bats in greasewood and riparian (up to 2.00 per ha in August). Mule deer were recorded on riparian sampling sites during the summer and fall, with estimated densities of up to 0.40 per ha.

Rodent population densities, determined by live-trapping grids in the four major vegetation types, were highest in greasewood (62.4 rodents per ha for species densities that could be meaningfully estimated), followed by shadscale (42.3), juniper (28.5), and riparian (1.4) (Table IV-24). Five of the 11 mammal species captured on the grids had estimated population densities of 10 or more animals per ha on one or more sampling sites: the deer mouse (Figure IV-12) in greasewood (23.4), juniper (12.4), and shadscale (18.2); the Apache

TABLE IV-24

RODENT DENSITIES AS DETERMINED BY LIVE-TRAPPING GRIDS IN FOUR VEGETATION TYPES DURING AUGUST, 1975

Sampling Site	Rodent (Species)	Number Captured	$\bar{X}$ Home-Range Size (ha)	Number Per Ha	95% Conf. Interval
Primary Greasewood	Desert Cottontail	2			
	Whitetail Antelope Squirrel	10	0.7	0.4	
	Desert Woodrat	2	0.2	1.4	
	Ord Kangaroo Rat	16	0.04	16.0	11-23
	Colorado Chipmunk	1			
	Deer Mouse	25	0.4	23.4	17-34
	Apache Pocket Mouse	19	0.7	21.2	12-34
Primary Juniper	Desert Woodrat	18	0.2	15.1	11-22
	Deer Mouse	13	1.1	12.4	8-19
	Apache Pocket Mouse	7	0.2	0.4	
	Pinyon Mouse	4	0.2	0.6	
	Whitetail Antelope Squirrel	2			
	Least Chipmunk	2			
	Desert Cottontail	1			
Primary Shadscale	Deer Mouse	19	0.5	18.2	12-26
	Whitetail Antelope Squirrel	16	0.3	22.3	9-46
	Ord Kangaroo Rat	7	0.2	0.4	
	Apache Pocket Mouse	6	0.2	0.7	
	Desert Woodrat	1	0.7	0.7	
	Brush Mouse	1			
Primary Riparian	Apache Pocket Mouse	1			
	Bushytail Woodrat	2			
	Desert Woodrat	1	0.3	1.0	
	Deer Mouse	8	0.4	0.4	

"Blanks" indicate insufficient data for meaningful determination.

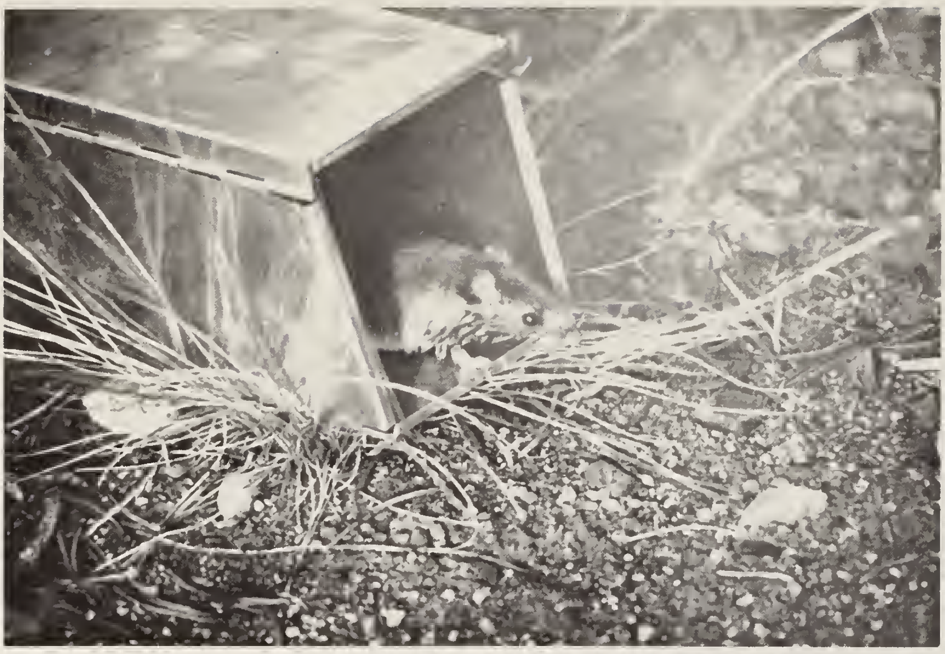


FIGURE IV-12 DEER MOUSE (PEROMYSCUS MANICULATUS) ESCAPING FROM SHERMAN LIVE TRAP.

FIGURE IV-13 APACHE POCKET MOUSE (PEROGNATHUS APACHE) FROM SAGEBRUSH/GREASEWOOD TRAPPING GRID.

pocket mouse (Figure IV-13) in greasewood (21.2); the Ord kangaroo rat in greasewood (16.0); the desert woodrat in juniper (15.1); and the whitetail antelope squirrel in shadscale (22.3).

Data from the live-trapping transects indicated that rodent populations increased from June to August in all four major vegetation types (Table IV-25). Results from the month of October suggested that rodent populations remained fairly stable from August to October. In June and August, numbers of individuals captured per 100 trap nights were relatively high on the greasewood and juniper sites and on the riparian greasewood site (ranging from 12.50 to 23.33 in June and from 14.99 to 24.98 in August), and generally were lower on the shadscale sites and on riparian sites along the White River (4.16 to 8.33 in June and 8.32 to 15.83 in August). The deer mouse was the most captured rodent in all major vegetation types.

No rare or endangered mammal species were recorded on or near the tracts during the first year of the sampling program.

Discussion

Seasonal variations in the number of mammal species on the tracts were recorded primarily because there is no suitable sampling technique for detecting the presence of certain species during the colder months. This was especially the case for nocturnal or hibernating rodents. The number of species observed varied little from one vegetation type to another, although the species composition of each major community differed somewhat. Species that use a wide range of habitats (e.g., deer mice) or that could cover relatively large distances easily (e.g., mule deer) were found in all four major vegetation types; whereas those with specialized habitat requirements (e.g., beaver and pinyon mice) were restricted to a single vegetation type.

Diurnal-mammal population densities, estimated from data collected during transect walks, increased during the spring and summer reproductive season and decreased at other times. For most species, decreases in density were due to mortality; however, some mule deer may have moved on and off the tracts seasonally, and certain species active during the summer hibernated in winter (e.g., golden-mantled squirrels). Data from the rodent-trapping transects indicated that the expected, cyclical seasonal pattern of population fluctuation for diurnal mammals also applied for nocturnal rodents.

TABLE IV-25

NUMBERS OF RODENTS CAPTURED BY LIVE-TRAPPING TRANSECTS ON 12 SITES IN FOUR VEGETATION TYPES

		Date															
		April 1975				June 1975				August 1975				October 1973			
Sampling Site	Rodent (Species)	Number of Captures	Number of Captures per 100 Trap Nights	Number of Animals	Number of Animals per 100 Trap Nights	Number of Captures	Number of Captures per 100 Trap Nights	Number of Animals	Number of Animals per 100 Trap Nights	Number of Captures	Number of Captures per 100 Trap Nights	Number of Animals	Number of Animals per 100 Trap Nights	Number of Captures	Number of Captures per 100 Trap Nights	Number of Animals	Number of Animals per 100 Trap Nights
Primary Greasewood	Apache Pocket Mouse	6	5.00			14	11.66	6	5.00								
	Ord Kangaroo Rat	6	5.00			18	14.99	6	5.00								
	Deer Mouse	30	24.99			36	29.99	16	13.33								
	Total	42	34.99			68	56.64	28	23.33								
Secondary Greasewood	Apache Pocket Mouse	8	6.66			11	9.16	6	5.00	9	7.50	4	3.33				
	Ord Kangaroo Rat	1	0.83			--	-----	--	--	--	--	--	--				
	Western Harvest Mouse	--	-----			3	2.50	2	1.67	--	--	--	--				
	Deer Mouse	13	10.83			11	9.16	7	5.83	34	28.32	14	11.66				
	Desert Woodrat	--	----			1	0.83	1	0.83	--	--	--	--				
	Total	22	18.32			26	21.65	16	13.33	43	35.82	18	14.99				
Off-Tract Greaswood	Whitetail Antelope Squirrel	--	--			--	--	--	--	3	2.50	3	2.50	--	--	--	--
	Golden-Mantled Squirrel	--	--			1	1.04	1	1.04	--	--	--	--	--	--	--	--
	Apache Pocket Mouse	3	3.13			1	1.04	1	1.04	5	4.16	4	3.33	24	19.99	12	10.0
	Ord Kangaroo Rat	1	1.04			1	1.04	1	1.04	5	4.16	1	0.83	--	--	--	--
	Western Harvest Mouse	3	3.13			2	2.08	1	1.04	--	--	--	--	--	--	--	--
	Deer Mouse	18	18.76			17	17.71	8	8.34	27	22.49	13	10.83	33	27.49	13	10.8
	Desert Woodrat	--	--			--	--	--	--	1	0.83	1	0.83	7	5.83	2	1.6
	Total	25	26.06			22	22.91	12	12.50	41	34.14	22	18.32	64	53.31	27	22.5
Primary Juniper	Colorado Chipmunk	--	--			2	1.67	1	0.83								
	Apache Pocket Mouse	1	1.04			1	0.83	1	0.83								
	Deer Mouse	16	16.67			10	8.33	4	3.33								
	Pinyon Mouse	--	--			15	12.50	6	5.00								
	Desert Woodrat	1	1.04			3	2.50	2	1.67								
	Unidentified, Cricetidae	5	5.21			--	--	--	--								
	Total	23	23.96			31	25.83	14	11.66								

TABLE IV-25 (cont.)

		Date															
		April				June 1975				August 1975				October 1975			
Sampling Site	Rodent (Species)	Numbers of Captures	Number of Captures per 100 Trap Nights	Number of Animals	Number of Animals per 100 Trap Nights	Number of Captures	Number of Captures per 100 Trap Nights	Numbers of Animals	Number of Animals per 100 Trap Nights	Number of Captures	Number cf Captures per 100 Trap Nights	Number of Animals	Number of Animals per 100 Trap Nights	Number of Captures	Number of Captures per 100 Trap Nights	Number of Animals	Number of Animals per 100 Trap Nights
Secondary Juniper	Colorado Chipmunk	--	--			--	--	--	--	--	--	--	--	1	0.83	1	0.83
	Apache Pocket Mouse	5	4.16			8	8.34	5	5.21	12	10.00	8	6.66	21	17.49	7	5.83
	Western Harvest Mouse	1	0.83			--	--	--	--	--	--	--	--	--	--	--	--
	Deer Mouse	20	16.66			14	14.59	7	7.29	21	17.49	9	7.50	10	8.33	4	3.33
	Pinyon Mouse	6	5.00			4	4.17	2	2.08	3	2.50	3	2.50	1	0.83	1	0.83
	Desert Woodrat	--	--			1	1.04	1	1.04	1	0.83	1	0.83	14	11.66	4	3.33
	Unidentified, Cricetidae	2	1.67			1	1.04	1	1.04	--	--	--	--	--	--	--	--
	Total	34	28.32			28	29.18	16	16.66	37	30.82	21	17.49	47	39.14	17	14.15
Off-Tract Juniper	Whitetail Antelope Squirrel	--	--			1	0.83	1	0.83	--	--	--	--				
	Golden-Mantled Squirrel	--	--			1	0.83	1	0.83	--	--	--	--				
	Colorado Chipmunk	--	--			9	7.50	4	3.33	10	8.33	4	3.33				
	Apache Pocket Mouse	6	5.00			1	0.83	1	0.83	1	0.83	1	0.83				
	Deer Mouse	35	29.16			29	24.16	11	9.16	23	19.16	8	6.66				
	Brush Mouse	--	--			--	--	--	--	4	3.33	1	0.83				
	Pinyon Mouse	--	--			--	--	--	--	7	5.83	3	2.50				
	Desert Woodrat	2	1.67			4	3.33	1	0.83	16	13.33	4	3.33				
	Total	43	35.83			45	37.48	19	15.81	61	50.81	21	17.48				
Primary Shadscale	Apache Pocket Mouse	1	0.83			--	--	--	--								
	Ord Kangaroo Rat	--	--			3	2.50	1	0.83								
	Deer Mouse	24	19.99			14	11.66	8	6.66								
	Unidentified, Cricetidae	4	3.33			--	--	--	--								
	Total	29	24.15			17	14.16	9	7.49								
Secondary Shadscale	Apache Pocket Mouse	--	--			--	--	--	--	8	6.66	4	3.33				
	Ord Kangaroo Rat	--	--			--	--	--	--	1	0.83	1	0.83				
	Deer Mouse	27	22.49			14	11.66	9	7.50	22	18.33	9	7.50				
	Unidentified, Cricetidae	4	3.33			--	--	--	--	--	--	--	--				
	Total	31	25.82			14	11.66	9	7.50	31	25.82	14	11.66				

TABLE IV-25 (cont.)

		Date															
		April 1975				June 1975				August 1975				October 1975			
Sampling Site	Rodent (Species)	Number of Captures	Number of Captures per 100 Trap Nights	Number of Animals	Number of Animals per 100 Trap Nights	Number of Captures	Number of Captures per 100 Trap Nights	Number of Animals	Number of Animals per 100 Trap Nights	Number of Captures	Number of Captures per 100 Trap Nights	Number of Animals	Number of Animals per 100 Trap Nights	Number of Captures	Number of Captures per 100 Trap Nights	Number of Animals	Number of Animals per 100 Trap Nights
Off-Tract Shadscale	Whitetail Antelope Squirrel					--	--	--	--	2	1.67	2	1.67				
	Apache Pocket Mouse					1	0.83	1	0.83	1	0.83	1	0.83				
	Ord Kangaroo Rat					3	2.50	1	0.83	11	9.16	3	2.50				
	Deer Mouse					14	11.66	7	5.83	31	25.82	11	9.16				
	Desert Woodrat					--	--	--	--	4	3.33	2	1.67				
	Total					18	14.99	9	7.50	49	40.81	19	15.83				
Primary Riparian	Deer Mouse	--	--			11	9.16	5	4.16					18	14.99	6	5.00
	Total	0	0.00			11	9.16	5	4.16					18	14.99	6	5.00
Off-Tract Riparian	Apache Pocket Mouse	3	2.50			--	--	--	--	1	0.83	1	0.83	4	3.33	2	1.67
	Deer Mouse	7	5.83			21	17.49	9	7.50	21	17.49	8	6.66	7	5.83	5	4.16
	Bushytail Woodrat	--	--			--	--	--	--	1	0.83	1	0.83	--	--	--	--
	Desert Cottontail (Lagomorpha)	--	--			1	0.83	1	0.83	--	--	--	--	--	--	--	--
	Total	10	8.33			22	18.32	10	8.33	23	19.15	10	8.32	11	9.16	7	5.83
Riparian Greasewood	Ord Kangaroo Rat					5	4.16	3	2.50	10	8.33	5	4.16				
	Deer Mouse					33	27.49	13	10.83	71	59.14	24	19.99				
	Bushytail Woodrat					--	--	--	--	2	1.67	1	0.83				
	Total					38	31.65	16	13.33	83	69.14	30	24.98				

The estimated population densities of diurnal native mammals were highest in the more complex vegetation types (i.e., greasewood and riparian) and were lowest in the least complex type (i.e., shadscale). Rodent population densities, estimated from the August trapping grid data, were much lower in the riparian vegetation type than in any other type; one of several factors responsible for this might be the relatively cold, damp winter weather conditions near the White River. The estimated rodent densities on the shadscale sites were inflated by a whitetail antelope squirrel colony. The highest rodent densities were on the greasewood site, where seeds were probably plentiful and where soils were relatively deep and sandy.

It is not known whether or not the denisty of any mammal species in 1975 was above, below, or equal to the long-term average since no such information exists prior to initiating these baseline studies. Since no species with irruptive population dynamics were seen on the tracts, the populations densities may be relatively stable from year to year. The estimated densities of nocturnal-rodent populations were several times higher on the tracts than in some other arid areas of Utah. Sagebrush and shadscale-sagebrush communities in Curlew Valley, Utah-Idaho, were estimated to contain about 10 and 25 animals per ha, respectively (Balph 1973).

d. Birds

Summary of Results

From December 1974 through November 1975, 106 species of birds were observed on or within 1.6 km (1 mi) of the tracts. Unconfirmed identifications were made of 8 additional species, for a total of 114 species (Table IV-26). The number of species recorded was greatest during spring and summer (64 verified species in April, 76 in June, and 53 in August), intermediate in fall (42 species in October), and least during winter (19 species in December and 21 in February). Of the four major vegetation types, the riparian type contained the largest number of species (a total of 93 verified species), followed by greasewood (58), juniper (49), and shadscale (38).

The densities of bird populations, estimated from data collected on transect walks, were low in all vegetation types during December and February, varying from 0.00 to 2.47 birds per ha on the sampling sites (Table IV-27). Population densities increased markedly from February to April and again from April to June. These increases were greatest in the

TABLE IV-26

AVIAN SPECIES LIST FROM OBSERVATIONS ON OR WITHIN 1.6 KM (1 MILE) OF UTAH OIL SHALE TRACTS, DECEMBER 1974 THROUGH OCTOBER 1975.

X = bird observed, G = greasewood, J = juniper, S = shadscale, R = riparian

	Date/Vegetation Type																							
	December 1974				February 1975				April 1975				June 1975				August 1975				October 1975			
Bird (Order/Species)	G	J	S	R	G	J	S	R	G	J	S	R	G	J	S	R	G	J	S	R	G	J	S	R
Ciconiiformes																								
Great Blue Heron	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-
Anseriformes																								
Common Merganser	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-
Mallard	-	-	-	-	X	-	-	-	-	-	-	X	-	-	-	X	-	-	-	-	-	-	-	-
Gadwall	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	X	-	-	-	-	-	-	-	-
American Widgeon	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-
Green-winged Teal	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-
Northern Shoveler	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-
Canada Goose	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	X	-	-	-	-	-	-	-	-
Falconiformes																								
Turkey Vulture	-	-	-	-	-	-	-	-	X	X	-	X	X	-	X	X	-	-	X	X	-	-	-	-
Marsh Hawk	-	-	-	-	-	-	X	-	-	-	X	-	X	-	X	-	X	-	-	X	X	-	X	-
Cooper's Hawk	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	X	-	-	-	X
Goshawk	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Red-tailed Hawk	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	-	X	X	X	-	X	-
Golden Eagle	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	-
Bald Eagle	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Prairie Falcon	-	-	-	-	-	-	-	-	X	X	-	-	X	X	X	X	X	X	X	-	X	X	X	X
Peregrine Falcon	-	X	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	X	-	-	-	-
American Kestrel	X	-	-	X	-	-	-	-	X	-	X	X	X	X	X	X	X	X	X	-	X	X	X	-
Gruiformes																								
Sandhill Crane	-	-	-	-	-	-	-	-	-	-	X	X	-	-	-	-	-	-	-	-	-	-	-	X
Chadriiformes																								
Common Snipe	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-
Spotted Sandpiper	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	X	-	-	-	-
Killdeer	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	X	-	-	-	X	-	-	-	-
Columbiformes																								
Mourning Dove	-	-	-	-	-	-	-	-	X	-	-	X	X	X	X	X	X	X	X	X	X	X	X	X

TABLE IV-26 (cont.)

Bird (Order/Species)	Date/Vegetation Type December 1974				February 1975				April 1975				June 1975				August 1975				October 1975			
	G	J	S	R	G	J	S	R	G	J	S	R	G	J	S	R	G	J	S	R	G	J	S	R
Strigiformes																								
Long-eared Owl	-	-	-	-	-	-	-	X	-	-	-	-	-	-	?	?	-	-	?	?	-	-	-	-
Short-eared Owl	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-
Great Horned Owl	-	X	-	-	-	X	-	-	-	-	-	-	-	-	?	?	-	X	?	X	-	-	-	X
Caprimulgiformes																								
Poor-will	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-
Common Nighthawk	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	-	-	-	-
Lesser Nighthawk	-	-	-	-	-	-	-	-	-	-	-	-	?	?	?	-	-	-	-	-	-	-	-	-
Apodiformes																								
White-throated Swift	-	-	-	-	-	-	-	-	-	-	-	X	X	-	-	X	X	X	-	X	-	-	-	-
Black-chinned Hummingbird	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	?	-	-	-	?	-	-	-	-
Broad-tailed Hummingbird	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	X	-	-	-	?	-	-	-	-
Coraciiformes																								
Belted Kingfisher	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X
Piciformes																								
Hairy Woodpecker	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Downy Woodpecker	-	-	-	-	-	-	-	X	-	-	-	X	-	-	-	X	-	-	-	X	-	-	-	X
Yellow-bellied Sapsucker	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	X	-	-	-	-	-	-	-	X
Common Flicker	X	-	-	X	-	-	-	X	X	X	-	X	-	X	-	X	X	-	-	X	-	X	-	X
Passeriformes																								
Eastern Kingbird	-	-	-	-	-	-	-	-	-	-	-	-	?	-	-	X	-	-	-	-	-	-	-	-
Western Kingbird	-	-	-	-	-	-	-	-	X	-	X	-	X	X	-	-	X	-	-	-	-	-	-	-
Ash-throated Flycatcher	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	X	-	-	-	X	-	-	-	-
Say's Phoebe	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	X	X	X	X	-	-	-	-
Western Wood Pewee	-	-	-	-	-	-	-	-	-	-	-	-	-	?	-	X	-	?	-	-	-	-	-	-
Willow Flycatcher	-	-	-	-	-	-	-	-	-	-	-	-	?	-	-	X	-	-	-	-	-	-	-	-
Gray Flycatcher	-	-	-	-	-	-	-	-	-	X	-	-	X	X	-	?	X	X	-	?	-	-	-	-
Horned Lark	-	-	X	-	X	-	X	-	X	-	X	-	-	X	X	-	-	-	X	-	X	X	X	X
Cliff Swallow	-	-	-	-	-	-	-	-	-	-	-	-	X	-	X	X	-	-	X	X	-	-	-	-
Barn Swallow	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
Tree Swallow	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	?	-	-	-	-	-	-	-	-
Violet-green Swallow	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	-	-	X	-	-	-	-
Rough-winged Swallow	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	X	X	-	X	X	-	-	-	-
Black-billed Magpie	-	X	X	X	X	X	-	X	X	X	X	X	X	X	X	X	-	-	-	X	X	X	X	X

TABLE IV-26 (cont.)

Bird (Order/Species)	Date/Vegetation Type																							
	December 1974				February 1975				April 1975				June 1975				August 1975				October 1975			
	G	J	S	R	G	J	S	R	G	J	S	R	G	J	S	R	G	J	S	R	G	J	S	R
Passeriformes (continued)																								
Scrub Jay	X	X	-	-	X	X	-	-	-	X	-	-	-	X	-	-	-	-	-	-	-	-	-	-
Common Raven	-	X	-	X	X	-	-	X	-	X	X	-	X	X	X	X	-	-	-	-	-	-	X	-
Clark's Nutcracker	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-
Pinyon Jay	-	X	-	-	X	X	-	-	X	X	-	-	X	X	X	X	X	X	-	-	X	X	-	-
Plain Titmouse	-	X	-	-	-	X	-	-	-	X	-	-	X	X	-	-	-	-	-	-	X	X	-	-
Black-capped Chickadee	-	-	-	X	-	-	-	X	-	-	-	X	-	-	-	X	-	-	-	X	-	-	-	X
Bushtit	X	X	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	?	-	X
Rock Wren	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	-
Canyon Wren	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-
House Wren	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	?	-	-	-	-	-	-	-	-
Sage Thrasher	-	-	-	-	-	-	-	-	-	-	X	-	X	X	X	-	X	-	X	-	X	-	X	-
Townsend's Solitaire	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	X
Swainson's Thrush	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X
American Robin	-	-	-	-	-	X	-	-	X	X	X	X	-	-	-	X	X	-	-	X	-	-	-	X
Western Bluebird	-	-	-	-	-	-	-	-	-	X	-	X	-	-	-	-	-	-	-	-	-	-	-	-
Mountain Bluebird	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	X	-	-	-	X	X	X	-
Ruby-crowned Kinglet	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	X
Blue-gray Gnatcatcher	-	-	-	-	-	-	-	-	-	-	-	X	X	X	-	X	X	X	-	X	-	-	-	-
Black-tailed Gnatcatcher	-	-	-	-	-	-	-	-	-	-	-	?	?	?	-	?	-	-	-	?	-	-	-	-
Water Pipit	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-
Cedar Waxwing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-
Loggerhead Shrike	X	-	X	X	-	-	X	-	X	-	X	X	X	-	X	-	X	-	X	-	X	-	X	-
Starling	-	-	-	-	-	-	-	-	-	-	X	X	-	-	X	X	-	-	X	-	-	-	-	-
Red-eyed Vireo	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	?	-	-	-	-	-	-	-	-
Warbling Vireo	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	X	-	-	-	-
Solitary Vireo	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-
Virginia's Warbler	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	X	-	-	-	-	-	-	-	-
Orange-crowned Warbler	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	X	-	-	-	-	-	-	-	-
Yellow Warbler	-	-	-	-	-	-	-	-	-	-	-	-	X	-	X	X	-	-	-	X	-	-	-	-
Yellow-rumped Warbler	-	-	-	-	-	-	-	-	-	-	-	X	X	X	-	X	-	-	-	-	-	-	-	-
Black-throated Gray Warbler	-	-	-	-	-	-	-	-	-	-	-	X	X	X	-	X	-	-	-	X	-	-	-	-
MacGillivray's Warbler	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	X	-	-	-	-	-	-	-	-
Common Yellowthroat	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-
Yellow-breasted Chat	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	X	-	-	-	-
Wilson's Warbler	-	-	-	-	-	-	-	-	-	-	-	X	X	-	-	X	-	-	-	X	-	-	-	-
Brown-headed Cowbird	-	-	-	-	-	-	-	-	-	-	-	-	X	X	-	X	-	-	-	-	-	-	-	-

TABLE IV-26 (cont.)

Bird (Order/Species)	Date/Vegetation Type December 1974				February 1975				April 1975				June 1975				August 1975				October 1975			
	G	J	S	R	G	J	S	R	G	J	S	R	G	J	S	R	G	J	S	R	G	J	S	R
Passeriformes (continued)																								
Red-winged Blackbird	-	-	-	-	-	-	-	-	X	X	-	X	X	-	-	X	-	-	-	-	-	-	-	-
Western Meadowlark	-	-	-	-	-	-	-	-	X	-	X	X	X	X	X	X	X	-	X	-	X	-	X	X
Scott's Oriole	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	-	-	-	-	-	-
Northern Oriole	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-
Brewer's Blackbird	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	-	-	-	-	-	-	-	X
Western Tanager	-	-	-	-	-	-	-	-	-	-	-	-	X	X	-	X	-	-	-	X	-	-	-	-
House Finch	-	-	-	-	-	-	-	-	-	X	-	-	X	X	X	X	X	-	-	X	-	X	-	-
Gray-crowned Rosy Finch	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Black Rosy Finch	-	-	-	X	-	-	-	X	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-
American Goldfinch	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-
Pine Siskin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X
Vesper Sparrow	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-
Lark Sparrow	-	-	-	-	-	-	-	-	X	-	X	-	X	X	X	X	X	-	X	X	X	X	-	-
White-crowned Sparrow	-	-	-	-	-	-	-	-	-	-	-	X	X	-	X	X	-	-	-	-	X	X	-	X
Tree Sparrow	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X
Chipping Sparrow	-	-	-	-	-	-	-	-	-	X	X	-	X	X	-	X	-	X	-	-	X	X	-	X
Brewer's Sparrow	-	-	-	-	-	-	-	-	-	-	X	-	X	X	X	X	X	X	X	X	-	-	-	-
Dark-eyed Junco	X	-	X	X	-	-	-	X	X	X	X	X	-	X	-	-	-	-	-	-	X	X	-	X
Gray-headed Junco	-	-	-	-	-	-	-	-	-	-	-	?	-	-	-	-	-	-	-	-	-	-	-	-
Black-throated Sparrow	-	-	-	-	-	-	-	-	X	-	X	-	X	X	X	X	X	X	X	X	-	-	-	-
Sage Sparrow	-	-	-	-	-	-	-	-	X	-	X	-	X	X	X	-	X	X	X	X	X	X	X	X
Song Sparrow	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	X	-	-	-	-	-	-	-	X
Rufous-sided Towhee	-	-	-	-	-	-	-	-	X	X	-	X	X	-	-	X	X	-	-	X	X	-	-	X
Green-tailed Towhee	-	-	-	-	-	-	-	-	X	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-
Black-headed Grosbeak	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	?	-	-	-	-
Blue Grosbeak	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-
Lazuli Bunting	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	X	-	-	-	-

TABLE IV-27

BIRD DENSITIES AS DETERMINED BY FLUSHING TRANSECTS ON 12 SITES IN FOUR VEGETATION TYPES

"Blanks" Indicate Insufficient Data for Meaningful Determination

		Date																	
		December 1974			February 1975			April 1975			June 1975			August 1975			October 1975		
Sampling Site	Bird (species)	Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval
Primary Greasewood	Golden Eagle	1	T		3	0.01		--	--		--	--		--	--		--	--	
	American Kestrel	--	--		--	--		--	--		--	--		--	--		1	0.20	
	Mourning Dove	--	--		--	--		--	--		6	0.60		12	0.75	0.32-1.18	--	--	
	Western Kingbird	--	--		--	--		2	0.03		1	0.04		--	--		--	--	
	Say's Phoebe	--	--		--	--		--	--		--	--		1	0.05		--	--	
	Gray Flycatcher	--	--		--	--		--	--		2	0.13		--	--		--	--	
	Black-billed Magpie	--	--		3	0.04		--	--		4	0.20		--	--		4	0.20	
	Scrub Jay	--	--		1	0.01		--	--		--	--		--	--		--	--	
	Common Raven	--	--		1	0.01		--	--		--	--		--	--		--		
	Pinyon Jay	--	--		44	0.59	0-1.74	--	--		40	7.44	0-18.62	34	5.00	0-13.83	99	19.27	0-44.33
	Plain Titmouse	--	--		--	--		--	--		3	0.20		--			2	0.05	
	Rock Wren	--	--		--	--		--	--		6	0.20		9	0.30		--	--	
	American Robin	--	--		--	--		2	0.03		--	--		--	--		--	--	
	Mountain Bluebird	--	--		--	--		3	0.05		7	0.17		--	--		--	--	
	Loggerhead Shrike	--	--		--	--		--	--		4	0.20		5	0.50		--	--	
	Western Meadowlark	--	--		--	--		--	--		2	0.03		--	--		--	--	
	Brewer's Blackbird	--	--		--	--		--	--		7	0.47		--	--		--	--	
	Lark Sparrow	--	--		--	--		--	--		5	1.00		--	--		--	--	
	White-crowned Sparrow	--	--		--	--		--	--		1	0.20	--	--	--		2	0.13	
	Chipping Sparrow	--	--		--	--		--	--		16	1.90	0.57-3.23	--	--		--	--	
	Brewer's Sparrow	--	--		--	--		--	--		15	2.10	1.32-2.88	--	--		--	--	
	Dark-eyed Junco	--	--		--	--		20	0.67	0-1.97	--	--		--	--		4	0.40	
	Black-throated Sparrow	--	--		--	--		--	--		5	1.00		1	0.20		--	--	
	Sage Sparrow	--	--		--	--		--	--		--	--		--	--		1	0.07	
	Unidentified, Accipitridae	--	--		1	0.02		--	--		--	--		--	--		--	--	
	Unidentified, Tyrannidae	--	--		--	--		--	--		1	0.20		--	--		--	--	
	Unidentified, Sylviidae	--	--		--	--		--	--		2	0.20		--	--		--	--	
	Unidentified, Icteridae	--	--		--	--		--	--		--	--		1	0.05		--	--	
	Unidentified, Fringillidae	--	--		--	--		1	0.05		7	0.80		4	0.40		--	--	
	Unidentified, Passeriformes	--	--		--	--		--	--		2	0.02		1	0.02		--	--	
	Total	1	T		53	0.68		28	0.83		136	17.10		68	7.27		123	20.32	

TABLE IV-27 (cont.)

		Date																	
		December 1974			February 1975			April 1975			June 1975			August 1975			October 1975		
Sampling Site	Bird (Species)	Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval
	Golden Eagle	1	T		--	--		--	--		--	--		--	--		1	0.01	
Secondary Greasewood	Prairie Falcon	--	--		--	--		--	--		1	0.40		--	--		--	--	
	Mourning Dove	--	--		--	--		--	--		3	0.20		3	1.20		--	--	
	Say's Phoebe	--	--		--	--		--	--		1	0.05		--	--		--	--	
	Horned Lark	--	--		--	--		--	--		--	--		--	--		15	3.76	0-10.74
	Black-billed Magpie	--	--		--	--		--	--		1	0.02		--	--		--	--	
	Pinyon Jay	--	--		--	--		12	0.58	0-1.64	--	--		--	--		--	--	
	Rock Wren	--	--		--	--		--	--		16	1.87	0.67-3.06	18	2.00	0.93-3.07	6	0.20	
	Mountain Bluebird	--	--		--	--		--	--		--	--		--	--		1	0.10	
	Western Meadowlark	--	--		--	--		--	--		--	--		--	--		1	0.05	
	House Finch	--	--		--	--		--	--		3	1.20		--	--		--	--	
	Lark Sparrow	--	--		--	--		--	--		--	--		4	0.53		--	--	
	Brewer's Sparrow	--	--		--	--		--	--		35	4.40	2.81-5.99	5	2.00		--	--	
	Black-throated Sparrow	--	--		--	--		--	--		10	2.07	0.04-4.10	10	2.27	0.30-4.23	--	--	
	Sage Sparrow	--	--		--	--		--	--		--	--		12	2.07	0-4.22	5	0.30	
	Green-tailed Towhee	--	--		--	--		1	0.07		--	--		--	--		--	--	
	Unidentified, Fringillidae	--	--		--	--		--	--		6	0.67		32	12.80		--	--	
	Unidentified, Passeriformes	--	--		--	--		3	0.04		1	0.40		--	--		1	0.40	
	Total	1	T		0	0.00		16	0.69		77	11.28		84	22.87		31	4.83	
Off-Tract Greasewood	Golden Eagle	--	--		--	--		--	--		--	--		--	--		2	0.40	
	Mourning Dove	--	--		--	--		3	0.80		3	0.20		80	12.43	5.65-1922	--	--	
	White-throated Swift	--	--		--	--		--	--		2	0.27		--	--		--	--	
	Say's Phoebe	--	--		--	--		--	--		--	--		15	2.60	0.78-4.42	--	--	
	Gray Flycatcher	--	--		--	--		--	--		2	0.40		1	0.07		--	--	
	Horned Lark	--	--		25	1.00	0-2.96	--	--		--	--		--	--		5	0.67	
	Violet-green Swallow	--	--		--	--		--	--		--	--		6	2.40		--	--	
	Pinyon Jay	--	--		--	--		--	--		1	0.40		--	--		--	--	
	Rock Wren	--	--		--	--		--	--		1	0.40		4	0.80		--	--	
	Sage Thrasher	--	--		--	--		--	--		--	--		3	0.80		--	--	
	Loggerhead Shrike	1	0.40		--	--		--	--		--	--		1	0.40		--	--	
	Red-winged Blackbird	--	--		--	--		--	--		4	1.60		--	--		--	--	
	Western Meadowlark	--	--		--	--		2	0.20		8	1.20		4	0.80		--	--	

TABLE IV-27 (cont.)

Sampling Site	Bird (Species)	December 1974 Number Observed	December 1974 Number per ha	December 1974 95% Confidence Interval	February 1975 Number Observed	February 1975 Number per ha	February 1975 95% Confidence Interval	April 1975 Number Observed	April 1975 Number per ha	April 1975 95% Confidence Interval	June 1975 Number Observed	June 1975 Number per ha	June 1975 95% Confidence Interval	August 1975 Number Observed	August 1975 Number per ha	August 1975 95% Confidence Interval	October 1975 Number Observed	October 1975 Number per ha	October 1975 95% Confidence Interval
Off-Tract Greasewood (continued)	Brewer's Blackbird	--	--		--	--		--	--		18	3.33	1.64-5.02	--	--		--	--	
	Western Tanager	--	--		--	--		--	--		1	0.20		--	--		--	--	
	Lark Sparrow	--	--		--	--		--	--		2	0.40		5	0.50		5	2.00	
	Chipping Sparrow	--	--		--	--		--	--		7	2.00		--	--		1	0.08	
	Brewer's Sparrow	--	--		--	--		--	--		1	0.40		59	18.90	2.34-35.46	--	--	
	Dark-eyed Junco	--	--		--	--		6	1.20		--	--		--	--		--	--	
	Black-throated Sparrow	--	--		--	--		--	--		3	0.24		--	--		--	--	
	Sage Sparrow	--	--		--	--		--	--		--	--		37	6.53	0-13.33	3	0.40	
	Rufous-sided Towhee	--	--		--	--		1	0.40		--	--		1	0.40		1	0.07	
	Unidentified, Tyrannidae	--	--		--	--		--	--		1	0.04		1	0.04				
	Unidentified, Fringillidae	--	--		--	--		4	0.40		--	--		5	2.00		2	0.80	
	Unidentified, Passeriformes	--	--		--	--		3	0.80		1	0.02		3	0.80				
	Total	1	0.40		25	1.00		19	3.80		55	11.10		225	49.47		19	4.42	
Primary Juniper	American Kestrel	--	--		--	--		--	--		1	0.02		--	--		--	--	
	Mourning Dove	--	--		--	--		--	--		17	0.83	0.16-1.50	13	1.03	0.56-1.51	--	--	
	Common Nighthawk	--	--		--	--		--	--		1	0.02		--	--		--	--	
	Say's Phoebe	--	--		--	--		--	--		1	0.10		--	--		--	--	
	Gray Flycatcher	--	--		--	--		--	--		11	0.84	0.21-1.46	1	0.04		--	--	
	Horned Lark	--	--		--	--		--	--		--	--		--	--		3	0.60	
	Black-billed Magpie	--	--		--	--		--	--		2	0.10		--	--		2	0.05	
	Scrub Jay	--	--		--	--		2	0.07		1	0.07		--	--		--	--	
	Common Raven	1	0.01		--	--		--	--		--	--		--	--		--	--	
	Clark's Nutcracker	--	--		--	--		--	--		--	--		--	--		6	1.20	
	Pinyon Jay	--	--		55	2.26	0-5.61	42	1.51	0-3.71	6	0.08		15	3.00	0-6.72	17	1.00	0-2.96
	Plain Titmouse	2	0.10		2	0.13		1	0.05		--	--		--	--		1	0.10	
	Bushtit	12	0.40	0-1.18	--	--		--	--		--	--		--	--		--	--	
	Rock Wren	--	--		--	--		1	0.02		11	0.51	0.20-0.81	4	0.20		3	0.10	
	Mountain Bluebird	--	--		--	--		4	0.05		5	0.13		--	--		3	0.40	
	Blue-gray Gnatcatcher	--	--		--	--		--	--		--	--		2	0.13		--	--	
	Black-throated Gray Warbler	--	--		--	--		--	--		14	0.92	0.43-1.40	--	--		--	--	
	Western Meadowlark	--	--		--	--		--	--		1	0.01		--	--		--	--	
	Brewer's Blackbird	--	--		--	--		--	--		2	0.40		--	--		--	--	

TABLE IV-27 (cont.)

Date

Sampling Site	Bird (Species)	December 1974			February 1975			April 1975			June 1975			August 1975			October 1975		
		Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval
Primary Juniper (continued)	Western Tanager	--	--		--	--		--	--		1	0.20		--	--		--	--	
	House Finch	--	--		--	--		--	--		9	0.40		--	--		1	0.20	
	Chipping Sparrow	--	--		--	--		--	--		5	0.27		16	1.42	0-2.84	--	--	
	Brewer's Sparrow	--	--		--	--		--	--		--	--		12	0.69	0-1.41	--	--	
	Dark-eyed Junco	--	--		--	--		3	0.15		--	--		--	--		2	0.40	
	Black-throated Sparrow	--	--		--	--		--	--		8	0.60		4	0.27		--	--	
	Sage Sparrow	--	--		--	--		--	--		--	--		1	0.20		--	--	
	Unidentified, Tyrannidae	--	--		--	--		--	--		2	0.20		--	--		--	--	
	Unidentified, Fringillidae	--	--		--	--		--	--		2	0.05		10	1.00		--	--	
	Unidentified, Passeriformes	--	--		--	--		--	--		4	0.20		1	0.02		2	0.40	
	Total	15	0.51		57	2.39		53	1.85		104	5.95		79	8.00		40	4.45	
Secondary Juniper	American Kestrel	--	--		--	--		--	--		1	0.08		--	--		--	--	
	Mourning Dove	--	--		--	--		--	--		5	1.20		3	0.80		--	--	
	Gray Flycatcher	--	--		--	--		--	--		2	0.40		1	0.40		--	--	
	Pinyon Jay	--	--		--	--		--	--		10	2.16	0-6.01	--	--		--	--	
	Plain Titmouse	1	0.40		1	0.08		3	1.20		--	--		--	--		--	--	
	Rock Wren	--	--		--	--		--	--		1	0.20		7	1.20		--	--	
	Sage Thrasher	--	--		--	--		--	--		1	0.13		--	--		--	--	
	Mountain Bluebird	--	--		--	--		3	0.30		7	0.53		--	--		8	2.00	
	Black-throated Gray Warbler	--	--		--	--		--	--		2	0.27		--	--		--	--	
	Brown-headed Cowbird	--	--		--	--		--	--		4	0.40		--	--		--	--	
	House Finch	--	--		--	--		--	--		17	3.20	0.53-5.87	--	--		--	--	
	Lark Sparrow	--	--		--	--		--	--		--	--		--	--		1	0.13	
	Chipping Sparrow	--	--		--	--		--	--		11	3.40	0.95-5.85	14	1.78	0.38-3.18	3	0.24	
	Brewer's Sparrow	--	--		--	--		--	--		6	0.80		--	--		--	--	
	Dark-eyed Junco	--	--		--	--		4	0.80		--	--		--	--		--	--	
	Black-throated Sparrow	--	--		--	--		--	--		3	0.40		--	--		--	--	
	Sage Sparrow	--	--		--	--		--	--		2	0.40		--	--		--	--	
	Rufous-sided Towhee	--	--		--	--		1	0.13		--	--		--	--		--	--	
	Unidentified, Tyrannidae	--	--		--	--		--	--		2	0.40		1	0.13		--	--	
	Unidentified, Sylviidae	--	--		--	--		--	--		1	0.10		--	--		--	--	
	Unidentified, Fringillidae	--	--		--	--		--	--		8	0.80		2	0.40		1	0.40	

TABLE IV-27 (cont.)

		Date																	
		December 1974			February 1975			April 1975			June 1975			August 1975			October 1975		
Sampling Site	Bird (Species)	Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval
Secondary Juniper (continued)	Unidentified, Passeriformes	--	--		--	--		3	1.20		3	0.40		--	--		--	--	
	Total	1	0.40		1	0.08		14	3.63		86	15.40		28	4.71		13	2.77	
Off-Tract Juniper	Golden Eagle	1	0.02		1	0.03		--	--		--	--		--	--		--	--	
	American Kestrel	--	--		--	--		--	--		1	0.40		1	0.13		--	--	
	Gray Flycatcher	--	--		--	--		--	--		--	--		1	0.40		--	--	
	Black-billed Magpie	1	0.03		7	0.14		--	--		5	1.20		--	--		--	--	
	Common Raven	2	0.05		--	--		--	--		--	--		--	--		--	--	
	Pinyon Jay	20	1.60	0-4.74	--	--		34	1.62	0.13-3.10	9	3.60		2	0.10		14	1.33	0-2.99
	Plain Titmouse	--	--		--	--		--	--		--	--		--	--		2	0.27	
	Rock Wren	--	--		--	--		--	--		5	1.20		1	0.05		--	--	
	American Robin	--	--		1	0.13		--	--		--	--		--	--		--	--	
	Mountain Bluebird	--	--		--	--		1	0.20		2	0.40		--	--		--	--	
	Black-throated Gray Warbler	--	--		--	--		--	--		3	1.20		--	--		--	--	
	Lark Sparrow	--	--		--	--		--	--		4	0.40		--	--		--	--	
	Chipping Sparrow	--	--		--	--		--	--		9	3.60		2	0.27		1	0.08	
	Dark-eyed Junco	--	--		--	--		18	1.58	0.09-3.07	--	--		--	--		2	0.13	
	Black-throated Sparrow	--	--		--	--		--	--		--			2	0.40		--	--	
	Sage Sparrow	--	--		--	--		--	--		--	--		--	--		1	0.40	
	Unidentified, Tyrannidae	--	--		--	--		--	--		1	0.08		--	--		--	--	
	Unidentified, Sylviidae	--	--		--	--		--	--		1	0.20		--	--		--	--	
	Unidentified, Fringillidae	--	--		--	--		--	--		1	0.40		2	0.40		3	1.20	
	Unidentified, Passeriformes	--	--		--	--		--	--		--	--		3	0.40		--	--	
	Total	24	1.70		9	0.30		53	3.40		41	12.68		14	2.15		23	3.41	
Primary Shadscale	Marsh Hawk	--	--		--	--		1	0.10		--	--		--	--		1	0.01	
	Golden Eagle	1	T		--	--		--	--		--	--		--	--		--	--	
	American Kestrel	--	--		--	--		--	--		1	0.02		1	0.20		--	--	
	Mourning Dove	--	--		--	--		--	--		5	0.80		4	0.20		--	--	
	Say's Phoebe	--	--		--	--		--	--		3	0.40		--	--		--	--	
	Horned Lark	--	--		--	--		--	--		--	--		--	--		61	12.20	0-25.93
	Barn Swallow	--	--		--	--		--	--		--	--		--	--		4	0.80	
	Violet-green Swallow	--	--		--	--		--	--		1	0.20		--	--		--	--	

TABLE IV-27 (cont.)

		Date																	
		December 1974			February 1975			April 1975			June 1975			August 1975			October 1975		
Sampling Site	Bird (Species)	Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval
Primary Shadscale (continued)	Rough-winged Swallow	--	--		--	--		--	--		--	--		6	1.20		--	--	
	Rock Wren	--	--		--	--		--	--		10	0.28	0.16-0.40	4	0.10		1	0.20	
	Sage Thrasher	--	--		--	--		--	--		7	0.40		2	0.07		--	--	
	Mountain Bluebird	--	--		--	--		15	0.94	0.15-1.73	1	0.20		--	--		--	--	
	Loggerhead Shrike	--	--		--	--		--	--		--	--		9	0.23		1	0.03	
	Starling	--	--		--	--		3	0.20		--	--		--	--		--	--	
	Western Meadowlark	--	--		--	--		3	0.06		21	0.84	0.53-1.15	8	0.80		--	--	
	Brewer's Blackbird	--	--		--	--		--	--		1	0.05		--	--		--	--	
	Lark Sparrow	--	--		--	--		--	--		7	0.13		2	0.20		--	--	
	Brewer's Sparrow	--	--		--	--		--	--		11	1.10	0.10-2.10	1	0.07		--	--	
	Dark-eyed Junco	--	--		--	--		4	0.20		--	--		--	--		--	--	
	Black-throated Sparrow	--	--		--	--		--	--		8	0.20		--	--		--	--	
	Sage Sparrow	--	--		--	--		17	1.51	0.60-2.43	14	1.40	0.40-2.40	7	1.00		--	--	
	Unidentified, Accipitridae	1	0.02		--	--		--	--		--	--		--	--		--	--	
	Unidentified, Fringillidae	--	--		--	--		--	--		12	0.80		1	0.20		--	--	
	Unidentified, Passeriformes	--	--		--	--		--	--		2	0.02		--	--		--	--	
	Total	2	0.02		0	0.00		43	3.01		104	6.84		45	4.27		68	13.24	
Secondary Shadscale	Marsh Hawk	--	--		2	0.05		--	--		--	--		--	--		--	--	
	Mourning Dove	--	--		--	--		--	--		--	--		7	2.80		--	--	
	Horned Lark	--	--		--	--		--	--		--	--		--	--		24	9.60	0-23.03
	Rough-winged Swallow	--	--		--	--		--	--		--	--		10	4.00	0-6.28	--	--	
	Rock Wren	--	--		--	--		--	--		2	0.10		--	--		--	--	
	Sage Thrasher	--	--		--	--		--	--		--	--		1	0.40		--	--	
	Mountain Bluebird	--	--		--	--		13	1.23	0-2.07	--	--		--	--		--	--	
	Loggerhead Shrike	--	--		--	--		--	--		6	0.48		2	0.13		--	--	
	Western Meadowlark	--	--		--	--		12	0.44	0.26-0.62	16	1.83	0.48-3.17	4	1.20		7	0.40	
	Lark Sparrow	--	--		--	--		--	--		4	0.80		6	1.60		--	--	
	Brewer's Sparrow	--	--		--	--		--	--		3	0.40		2	0.80		--	--	
	Dark-eyed Junco	--	--		--	--		3	0.20		--	--		--	--		--	--	
	Black-throated Sparrow	--	--		--	--		--	--		--	--		1	0.13		--	--	
	Sage Sparrow	--	--		--	--		14	2.27	0.49-4.05	3	0.40		--	--		3	0.60	
	Unidentified, Fringillidae	--	--		--	--		--	--		2	0.10		2	0.13		--	--	
	Unidentified, Passeriformes	--	--		--	--		--	--		2	0.20		--	--		--	--	
	Total	0	0.00		2	0.05		42	4.14		38	4.31		35	11.19		34	10.60	

TABLE IV-27 (cont.)

		Date																	
		December 1974			February 1975			April 1975			June 1975			August 1975			October 1975		
Sampling Site	Bird (Species)	Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval
Off-Tract Shadscale	Red-tailed Hawk	--	--		--	--		--	--		1	0.04		--	--		--	--	
	American Kestrel	--	--		--	--		1	0.03		--	--		1	0.05		--	--	
	Mourning Dove	--	--		--	--		--	--		3	1.20		4	1.20		--	--	
	Say's Phoebe	--	--		--	--		1	0.40		1	0.10					--	--	
	Horned Lark	--	--		--	--		--	--		--	--		--	--		29	11.60	0.08-23.12
	Rock Wren	--	--		--	--		1	0.02		--	--		1	0.05		--	--	
	Sage Thrasher	--	--		--	--		7	0.33		1	0.40		--	--		--	--	
	Mountain Bluebird	--	--		--	--		3	0.13		5	0.50		--	--		--	--	
	Loggerhead Shrike	--	--		1	0.07		--	--		--	--		--	--		1	0.08	
	Western Meadowlark	--	--		--	--		1	0.03		4	0.32		--	--		2	0.27	
	Brewer's Blackbird	--	--		--	--		1	0.20		--	--		--	--		--	--	
	Lark Sparrow	--	--		--	--		--	--		1	0.40		--	--		--	--	
	Chipping Sparrow	--	--		--	--		1	0.10		--	--		--	--		--	--	
	Brewer's Sparrow	--	--		--	--		--	--		13	4.20	2.63-5.77	1	0.40		--	--	
	Black-throated Sparrow	--	--		--	--		--	--		2	0.40		7	0.48		--	--	
	Sage Sparrow	--	--		--	--		25	4.27	0-11.01	7	2.80		3	0.27		6	1.60	
	Unidentified, Hirundinidae	--	--		--	--		1	0.20		--	--		--	--		--	--	
	Unidentified, Fringillidae	--	--		--	--		--	--		1	0.20		--	--		--	--	
	Total	0	0.00		1	0.07		42	5.71		39	10.56		17	2.45		38	13.55	
Primary Riparian	Common Merganser	--	--		--	--		1	0.40		--	--		--	--		--	--	
	Mallard	--	--		--	--		2	0.16		--	--		--	--		--	--	
	Green-winged Teal	--	--		--	--		4	0.53		--	--		--	--		--	--	
	Canada Goose	--	--		--	--		6	0.50		--	--		--	--		--	--	
	Cooper's Hawk	--	--		--	--		--	--		--	--		--	--		2	0.40	
	Golden Eagle	--	--		--	--		--	--		2	0.04		--	--		--	--	
	American Kestrel	--	--		--	--		1	0.03		--	--		--	--		--	--	
	Spotted Sandpiper	--	--		--	--		--	--		5	0.27		1	0.40		--	--	
	Killdeer	--	--		--	--		1	0.40		--	--		--	--		--	--	
	Mourning Dove	--	--		--	--		--	--		10	0.54	0.05-1.03	5	2.00		--	--	
	Long-eared Owl	--	--		1	0.20		--	--		--	--		--	--		--	--	
	Great Horned Owl	--	--		--	--		--	--		--	--		--	--		1	0.07	
	Downy Woodpecker	--	--		--	--		2	0.80		2	0.27		--	--		1	0.07	
	Yellow-bellied Sapsucker	--	--		--	--		--	--		--	--		--	--		1	0.07	

TABLE IV-27 (cont.)

		Date																	
		December 1974			February 1975			April 1975			June 1975			August 1975			October 1975		
Sampling Site	Bird (Species)	Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval
Primary Riparian (continued)	Common Flicker	2	0.50		--	--		1	0.03		2	0.40		2	0.40		2	0.27	
	Ash-throated Flycatcher	--	--		--	--		--	--		4	1.60		--	--		--	--	
	Say's Phoebe	--	--		--	--		2	0.16		--	--		--	--		--	--	
	Western Wood Pewee	--	--		--	--		--	--		1	0.07		--	--		--	--	
	Willow Flycatcher	--	--		--	--		--	--		1	0.07		--	--		--	--	
	Horned Lark	--	--		--	--		--	--		--	--		--	--		22	8.80	0-26.05
	Black-billed Magpie	--	--		--	--		--	--		2	0.20		--	--		5	1.60	
	Common Raven	--	--		3	0.04		--	--		--	--		--	--		--	--	
	Black-capped Chickadee	--	--		--	--		3	0.24		3	0.20		--	--		--	--	
	Rock Wren	--	--		--	--		--	--		1	0.07		--	--		--	--	
	Townsend's Solitaire	--	--		--	--		--	--		--	--		--	--		1	0.20	
	American Robin	--	--		--	--		11	1.29	0-2.60	3	0.40		--	--		1	0.40	
	Ruby-crowned Kinglet	--	--		--	--		--	--		--	--		--	--		1	0.40	
	Blue-gray Gnatcatcher	--	--		--	--		--	--		3	0.60		3	0.40		--	--	
	Starling	--	--		--	--		3	0.15		5	0.27		--	--		--	--	
	Warbling Vireo	--	--		--	--		--	--		6	0.40		--	--		--	--	
	Virginia's Warbler	--	--		--	--		--	--		2	0.40		--	--		--	--	
	Orange-crowned Warbler	--	--		--	--		--	--		1	0.10		--	--		--	--	
	Yellow Warbler	--	--		--	--		--	--		19	2.30	0.91-3.69	6	2.40		--	--	
	Yellow-rumped Warbler	--	--		--	--		3	0.40		--	--		--	--		--	--	
	Common Yellowthroat	--	--		--	--		--	--		1	0.40		--	--		--	--	
	Yellow-breasted Chat	--	--		--	--		--	--		1	0.08		--	--		--	--	
	Brown-headed Cowbird	--	--		--	--		--	--		21	2.59	0.56-4.62	--	--		--	--	
	Red-winged Blackbird	--	--		--	--		12	10.5	0-2.33	--	--		--	--		--	--	
	Western Meadowlark	--	--		--	--		3	0.24		6	0.30		--	--		--	--	
	Northern Oriole	--	--		--	--		--	--		3	0.40		--	--		--	--	
	Brewer's Blackbird	--	--		--	--		--	--		--	--		--	--		1	0.40	
	Western Tanager	--	--		--	--		--	--		3	0.15		1	0.40		--	--	
	House Finch	--	--		--	--		--	--		2	0.27		--	--		--	--	
	Lark Sparrow	--	--		--	--		--	--		4	1.60		--	--		--	--	
	Chipping Sparrow	--	--		--	--		--	--		3	0.80		--	--		--	--	
	Dark-eyed Junco	--	--		--	--		3	0.40		--	--		--	--		5	2.00	
	Rufous-sided Towhee	--	--		--	--		6	1.20		13	1.80	0.84-2.76	1	0.13		6	2.00	
	Black-headed Grosbeak	--	--		--	--		--	--		1	0.10		--	--		--	--	

TABLE IV-27 (cont.)

Sampling Site	Bird (Species)	December 1974 Number Observed	December 1974 Number per ha	December 1974 95% Confidence Interval	February 1975 Number Observed	February 1975 Number per ha	February 1975 95% Confidence Interval	April 1975 Number Observed	April 1975 Number per ha	April 1975 95% Confidence Interval	June 1975 Number Observed	June 1975 Number per ha	June 1975 95% Confidence Interval	August 1975 Number Observed	August 1975 Number per ha	August 1975 95% Confidence Interval	October 1975 Number Observed	October 1975 Number per ha	October 1975 95% Confidence Interval
Primary Riparian (continued)	Lazuli Bunting	--	--		--	--		--	--		7	0.60		--	--		--	--	
	Unidentified, Strigidae	--	--		--	--		--	--		1	0.03		--	--		--	--	
	Unidentified, Tyrannidae	--	--		--	--		--	--		2	0.40		1	0.40		--	--	
	Unidentified, Hirundinidae	--	--		--	--		--	--		--	--		3	1.20		--	--	
	Unidentified, Sylviidae	--	--		--	--		--	--		3	0.13		--	--		--	--	
	Unidentified, Vireonidae	--	--		--	--		--	--		1	0.40		1	0.08		--	--	
	Unidentified, Parulidae	--	--		--	--		--	--		4	0.20		--	--		--	--	
	Unidentified, Fringillidae	--	--		--	--		--	--		4	0.80		10	3.20		2	0.40	
	Unidentified, Charadriiformes	--	--		--	--		--	--		1	0.03		--	--		--	--	
	Unidentified, Passeriformes	--	--		--	--		--	--		7	0.53		--	--		4	0.30	
	Total	2	0.50		4	0.24		64	7.98		160	19.81		34	11.01		55	17.88	
Off-Tract Riparian	Gadwall	--	--		--	--		2	0.13		--	--		--	--		--	--	
	Canada Goose	--	--		--	--		7	1.60		2	0.40		--	--		--	--	
	Turkey Vulture	--	--		--	--		10	1.40	1.08-1.72	9	0.90		--	--		--	--	
	Goshawk	--	--		1	0.02		--	--		--	--		--	--		--	--	
	Red-tailed Hawk	--	--		--	--		2	0.08		--	--		1	0.04		--	--	
	Golden Eagle	--	--		--	--		1	0.01		--	--		--	--		--	--	
	American Kestrel	--	--		--	--		1	0.05		--	--		--	--		--	--	
	Spotted Sandpiper	--	--		--	--		--	--		3	0.40		5	0.33		--	--	
	Mourning Dove	--	--		--	--		6	0.60		15	0.88	0-1.97	20	4.52	2.46-6.58	5	0.40	
	Broad-tailed Hummingbird	--	--		--	--		--	--		1	0.40		--	--		--	--	
	Hairy Woodpecker	2	0.08		--	--		--	--		--	--		--	--		--	--	
	Downy Woodpecker	--	--		--	--		6	0.50		--	--		1	0.05		1	0.40	
	Yellow-bellied Sapsucker	--	--		--	--		--	--		--	--		--	--		7	0.67	
	Common Flicker	--	--		--	--		3	0.16		1	0.05		3	0.80		2	0.13	
	Western Wood Pewee	--	--		--	--		--	--		5	0.50		--	--		--	--	
	Cliff Swallow	--	--		--	--		--	--		390	23.00	17.12-28.88	--	--		--	--	
	Violet-green Swallow	--	--		--	--		--	--		1	0.40		--	--		--	--	
	Rough-winged Swallow	--	--		--	--		--	--		--	--		5	1.00		--	--	
	Black-billed Magpie	--	--		--	--		--	--		--	--		--	--		4	1.20	
	Black-capped Chickadee	--	--		--	--		--	--		3	0.40		--	--		--	--	
	Rock Wren	--	--		--	--		--	--		1	0.03		--	--		--	--	
	Swainson's Thrush	--	--		--	--		--	--		--	--		--	--		1	0.20	

TABLE IV-27 (cont.)

Date

Sampling Site	Bird (Species)	December 1974			February 1975			April 1975			June 1975			August 1975			October 1975		
		Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval
Off-Tract Riparian (continued)	American Robin	--	--		--	--		7	0.53		5	0.40		--	--		--	--	
	Blue-gray Gnatcatcher	--	--		--	--		--	--		--	--		1	0.20		--	--	
	Cedar Waxwing	--	--		--	--		--	--		1	0.04		--	--		--	--	
	Loggerhead Shrike	1	0.40		--	--		--	--		--	--		--	--		--	--	
	Starling	--	--		--	--		7	0.80		5	0.60		--	--		--	--	
	Virginia's Warbler	--	--		--	--		--	--		10	1.57	0.26-2.87	--	--		--	--	
	Orange-crowned Warbler	--	--		--	--		--	--		1	0.08		--	--		--	--	
	Yellow Warbler	--	--		--	--		--	--		35	4.23	2.80-5.67	7	2.40		--	--	
	Yellow-rumped Warbler	--	--		--	--		8	1.20		1	0.20		--	--		--	--	
	Black-throated Gray Warbler	--	--		--	--		--	--		--	--		3	0.40		--	--	
	Yellow-breasted Chat	--	--		--	--		--	--		8	0.80		3	0.[illegible]6		--	--	
	Wilson's Warbler	--	--		--	--		--	--		5	0.80		--	--		--	--	
	Brown-headed Cowbird	--	--		--	--		--	--		21	2.83	1.55-4.12	--	--		--	--	
	Red-winged Blackbird	--	--		--	--		3	0.20		--	--		--	--		--	--	
	Western Meadowlark	--	--		--	--		2	0.13		--	--		--	--		--	--	
	Northern Oriole	--	--		--	--		--	--		3	0.16		--	--		--	--	
	Western Tanager	--	--		--	--		--	--		4	0.80		--	--		--	--	
	House Finch	--	--		--	--		--	--		20	1.65	0.99-2.30	2	0.40		--	--	
	Lark Sparrow	--	--		--	--		--	--		--	--		22	3.93	0.88-6.99	--	--	
	White-crowned Sparrow	--	--		--	--		--	--		--	--		--			2	0.80	
	Chipping Sparrow	--	--		--	--		--	--		--	--		--	--		1	0.40	
	Brewer's Sparrow	--	--		--	--		--	--		--	--		5	0.50		--	--	
	Dark-eyed Junco	--	--		--	--		6	1.20		--	--		--	--		1	0.10	
	Rufous-sided Towhee	--	--		--	--		10	1.43	0.51-2.36	12	1.65	0.24-3.07	7	1.20		5	0.80	
	Green-tailed Towhee	--	--		--	--		2	0.80		--	--		--	--		--	--	
	Black-headed Grosbeak	--	--		--	--		--	--		7	0.47		--	--		--	--	
	Lazuli Bunting	--	--		--	--		--	--		15	4.15	0.20-8.09	--	--		--	--	
	Unidentified, Anatidae	--	--		--	--		--	--		3	0.30		--	--		--	--	
	Unidentified, Trochilidae	--	--		--	--		--	--		1	0.40		--	--		--	--	
	Unidentified, Tyrannidae	--	--		--	--		--	--		1	0.08		--	--		--	--	
	Unidentified, Hirundinidae	--	--		--	--		--	--		--	--		4	1.60		--	--	
	Unidentified, Parulidae	--	--		--	--		1	0.08		3	0.40		--	--		--	--	
	Unidentified, Fringillidae	--	--		--	--		4	0.40		--	--		2	0.80		3	0.80	
	Undentified, Passeriformes	2	0.05		--	--		--	--		5	0.13		3	0.08		2	0.80	
	Total	5	0.53		1	0.02		87	10.47		597	49.10		94	18.41		34	6.70	

TABLE IV-27 (cont.)

Sampling Site	Bird (Species)	December 1974 Number Observed	December 1974 Number per ha	December 1974 95% Confidence Interval	February 1975 Number Observed	February 1975 Number per ha	February 1975 95% Confidence Interval	April 1975 Number Observed	April 1975 Number per ha	April 1975 95% Confidence Interval	June 1975 Number Observed	June 1975 Number per ha	June 1975 95% Confidence Interval	August 1975 Number Observed	August 1975 Number per ha	August 1975 95% Confidence Interval	October 1975 Number Observed	October 1975 Number per ha	October 1975 95% Confidence Interval
Riparian Greasewood	Cooper's Hawk	--	--		--	--		--	--		--	--		1	0.20		--	--	
	Golden Eagle	2	T					3	0.02		1	0.40		--	--		--	--	
	American Kestrel	1	0.03		--	--		3	0.04		--	--		--	--		--	--	
	Killdeer	--	--		--	--		3	0.60		--	--		5	1.60		--	--	
	Mourning Dove	--	--		--	--		1	0.05		9	2.40		12	1.87	0-4.03	--	--	
	Common Flicker	--	--		--	--		--	--		--	--		--	--		2	0.13	
	Say's Phoebe	--	--		--	--		--	--		--	--		1	0.40		--	--	
	Violet-green Swallow	--	--		--	--		--	--		--	--		4	0.80		--	--	
	Black-billed Magpie	--	--		6	0.20		--	--		14	2.90	0.38-5.42	1	0.08		--	--	
	Bushtit	12	0.96	0-2.84	--	--		--	--		--	--		--	--		16	4.60	0-10.33
	Rock Wren	--	--		--	--		3	0.20		--	--		10	1.27	0.67-1.87	--	--	
	Townsend's Solitaire	--	--		--	--		--	--		--	--		--	--		3	0.40	
	American Robin	--	--		--	--		5	0.50		--	--		1	0.05		--	--	
	Mountain Bluebird	--	--		--	--		2	0.20		--	--		--	--		--	--	
	Blue-gray Gnatcatcher	--	--		--	--		--	--		2	0.40		6	2.00		--	--	
	Orange-crowned Warbler	--	--		--	--		1	0.08		--	--		--	--		--	--	
	Yellow-breasted Chat	--	--		--	--		--	--		4	0.53		--	--		--	--	
	Brewer's Blackbird	--	--		--	--		5	0.25		--	--		--	--		--	--	
	Western Tanager	--	--		--	--		--	--		--	--		1	0.40		--	--	
	House Finch	--	--		--	--		--	--		--	--		5	1.60		--	--	
	Pine Siskin	--	--		--	--		--	--		--	--		--	--		1	0.20	
	White-crowned Sparrow	--	--		--	--		6	2.00		--	--		--	--		5	1.20	
	Tree Sparrow	--	--		--	--		--	--		--	--		--	--		1	0.40	
	Chipping Sparrow	--	--		--	--		--	--		2	0.80		--	--		2	0.40	
	Brewer's Sparrow	--	--		--	--		--	--		11	3.40	0-6.88	33	11.20	6.80-15.60	--	--	
	Dark-eyed Junco	22	1.48	0-3.43	7	2.00		1	0.40		--	--		--	--		42	13.20	7.31-19.09
	Black-throated Sparrow	--			--	--		--	--		3	0.80		3	0.30		--	--	
	Sage Sparrow	--	--		--	--		--	--		--	--		1	0.13		8	1.60	
	Rufous-sided Towhee	--	--		--	--		22	4.20	1.85-6.55	16	3.20	2.24-4.16	15	4.27	1.84-6.70	1	0.20	
	Green-tailed Towhee	--	--		--	--		4	0.40		--	--		--	--		--	--	
	Lazuli Bunting	--	--		--	--		--	--		1	0.20		1	0.13		--	--	
	Unidentified, Trochilidae	--	--		--	--		--	--		--	--		1	0.40		--	--	
	Unidentified, Tyrannidae	--	--		--	--		--	--		--	--		1	0.10		--	--	
	Unidentified, Sylviidae	--	--		--	--		1	0.20		8	1.60		3	1.20		--	--	
	Unidentified, Parulidae	--	--		--	--		--	--		1	0.40		--	--		--	--	

TABLE IV-27 (cont.)

Sampling Site	Bird (Species)	Date: December 1974			February 1975			April 1975			June 1975			August 1975			October 1975		
		Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval
Riparian Greasewood (continued)	Unidentified, Fringillidae	--	--		--	--		--	--		1	0.20		9	1.60		--	--	
	Unidentified, Passeriformes	--	--		--	--		--	--		--	--		2	0.80		10	4.00	
	Total	37	2.47		13	2.20		60	9.14		73	17.23		116	30.40		91	26.33	

riparian vegetation type; on the off-tract riparian site, the number of birds per ha was estimated to be 0.02 in February, 10.47 in April, and 49.10 in June. Population densities decreased from June to August on most sampling sites but increased on a few sites, notably the off-tract greasewood site, where the estimated number of birds per ha rose from 11.10 in June to 49.47 in August.

The most abundant bird species on the sampling sites in December and February were pinyon jays in juniper (with estimated densities of up to 2.26 per ha) and dark-eyed juncos in riparian greasewood (2.00 per ha) (Table IV-27). In April these two species, as well as sage sparrows in shadscale (up to 4.27 per ha), were the most commonly seen. Twelve nesting pairs of Canada geese were recorded along the White River (off the tracts in the project area) during float trips in the spring (about 3.7 pairs per km of river traveled). In June, 14 species had estimated densities of two or more birds per ha on one or more sampling sites. The most abundantly represented species were pinyon jays in greasewood and juniper (up to 7.44 per ha), Brewer's sparrows in greasewood and shadscale (up to 4.40 per ha), yellow warblers in riparian (up to 4.23 per ha), and cliff swallows on the off-tract riparian site (23.00 per ha). In August, 12 species had estimated population densities of 2 or more birds per ha on 1 or more sampling sites. Particularly abundant were Brewer's sparrows in greasewood (up to 18.90 per ha), sage sparrows in greasewood (up to 6.53 per ha), pinyon jays in greasewood and juniper (up to 5.00 per ha), and mourning doves in greasewood and riparian (up to 12.43 per ha). Brewer's, sage, black-throated, and lark sparrows may have been more abundant than their population-density estimates indicated, since flocks of unidentified sparrows (Fringillidae) were commonly recorded on the August transect walks (Table IV-27). In October, seven species had estimated population densities of two or more birds per ha on one or more sampling sites. The most abundantly represented species were horned larks in greasewood, shadscale, and riparian (up to 12.20 per ha in shadscale) and dark-eyed juncos in riparian (up to 13.20 per ha).

A peregrine falcon, an endangered species, was sighted in the project area in December, April, and August. No peregrine falcon nests were found during a search by Utah Division of Wildlife Resources (DWR) or Bureau of Land Management (BLM) personnel.

Discussion

The number of bird species seen on the tracts varied markedly through the year, with four times as many species recorded in June as in December. These fluctuations were due primarily to migratory movements of many species. Although some species, such as dark-eyed juncos and black and gray-crowned rosy finches, were present on the tracts during the winter and migrated out of the area to breed, most of the migratory species were summer residents that vacated the area in the fall. Many of these summer residents were insectivorous passerines (e.g., several species of flycatchers, swallows, and warblers). Some other birds (e.g., sandhill cranes and several species of ducks) were on the tracts only during migration in the spring or fall. Certain uncommon resident species (e.g., several raptors), although not observed in all sampling periods, probably were present on the tracts throughout the year.

In all sampling periods, more bird species were recorded in the riparian vegetation type than in any other type. Greasewood usually ranked second in the number of species observed, juniper ranked third, and shadscale ranked fourth. It is believed that the differences in the number of avian species from one vegetation type to another can be attributed to differences in habitats within each major vegetation type. Riparian habitat ranged from shoreline to mature stands of cottonwood, which in turn bordered on rocky outcrops and shadscale or greasewood. Riparian areas thus supported birds with widely differing habitat requirements--e.g., Canada geese and spotted sandpipers along shorelines, yellow warblers in willow thickets, blackheaded grosbeaks and northern orioles in cottonwood stands, rock wrens in cliffs adjacent to riparian vegetation, and Brewer's sparrows in riparian greasewood habitat. In addition, some species such as mourning doves visited riparian areas regularly for water.

The shadscale vegetation type represented an opposite extreme in that it contained relatively large, unbroken areas of desert scrub habitat and supported a small number of species adapted to this particular habitat. The greasewood and juniper vegetation types, which adjoined or penetrated each other in many places, represented an intermediate environment. Ecotones, where greasewood and sagebrush gave way to juniper, contained species typical of sagebrush habitat as well as those typical of juniper habitat.

Total population densities of birds, estimated from data collected during transect walks, showed pronounced seasonal changes, peaking in June at the height of the reproductive season. Estimated species densities on the sampling sites in December and February averaged only 3 percent to 4 percent of those noted in June. Daily variations in estimated species densities seen on transect walks tended to be smaller in June than in other sampling periods, probably because many birds were territorial (hence relatively sedentary and uniformly spaced) during the nesting season but moved in flocks at other times.

Estimated population densities were about 5 percent lower on the average in August than in June. Any or all of several factors might have contributed to this decline. First, reproductive success may have been relatively poor for many species because of the unusually prolonged cold weather in the spring of 1975, which resulted in low recruitment of young into the populations during the summer. Second, some birds may have moved away from the tracts between June and August. For instance, swallows and warblers appeared to be far less abundant in August than in June; and it is possible that dry weather during the summer caused a decrease in the populations of small insects upon which these birds feed, thus prompting the birds to leave the area. Third, many species should have been less conspicuous in August than in June, for two reasons: (1) conspicuous reproductive behaviors, such as territorial advertisement and parental feeding of young, are absent in late summer; and (2) most birds undergo an extensive molt in late summer and they behave secretively. The fact that estimated bird densities dropped chiefly in vegetation types containing trees (i.e., juniper and riparian) suggests that the secretive behavior was at least partly responsible for the apparent reduction in bird numbers from June to August.

In most sampling periods, the most dense bird populations were recorded in riparian vegetation; the second highest population densities were recorded in greasewood vegetation. The total densities were usually lower in juniper and shadscale, except when sizable flocks of horned larks produced the high total density estimated on the shadscale sites in October. February-to-June increases in population densities were greatest on the riparian sites, mainly because of the many insectivorous summer residents that arrived in June to prey on the abundant flying insects near the White River. Population densities in the greasewood vegetation type generally increased from June to August, in contrast to densities in other vegetation types. This rise was the most pronounced on the off-tract greasewood site, where an influx of mourning doves and several species of sparrows produced more than a fourfold increase in total density. The August transect data for this site were collected shortly after a flow event; thus it seems likely that mourning doves were attracted by moisture in the area and that sparrow flocks congregated to feed on seeds washed down by the flood.

Estimated bird species densities on the tracts in the summer were about double those reported for the Desert Biome Program's validation sites in Curlew Valley, Utah-Idaho (Balph 1973). In June 1972 Curlew Valley bird density estimates in sagebrush and in shadscale-sagebrush communities were 15 percent and 31 percent, respectively, of those for the greasewood and shadscale sampling sites on the tracts. These differences can probably be attributed to the complexity of the tracts' environment relative to that of Curlew Valley.

e. Reptiles and Amphibians

Summary of Results

Between December 1974 and October 1975, 14 species of amphibians and reptiles were observed on or within 1.6 km (1 mi) of the tracts (Table IV-28). These species included three toads and frogs, six lizards, and five snakes. Unconfirmed observations were made of an additional species, the chorus frog. The number of amphibians and reptile species seen was greatest during the summer (12 verified species in June and 13 in August). Fewer species were noted in the spring and fall (four and nine species in April and October, respectively), and none were found aboveground during winter. Twelve verified species occurred in the riparian vegetation type, compared with eight species in each of the other three major vegetation types.

Amphibians were active from May through September and appeared to be restricted to the riparian community along the White River. No amphibians were found in Asphalt Wash or Evacuation Creek during flow events. The leopard frog was the only amphibian seen during the amphibian and reptile transect walks (Table IV-29). Biologists believe it to be the most common amphibian species on the tracts.

Lizards, observed from April through October, were the most abundant during summer. Four lizard species were recorded in all four major vegetation types: the eastern fence lizard, the sagebrush lizard, the side-blotched lizard, and the western whiptail. Conversely, the short-horned lizard was seen only in shadscale. The total aboveground densities of lizards, estimated from data collected during amphibian and reptile transect walks, increased from June to August on a majority of sampling sites (Table IV-29). The estimated aboveground densities generally were highest in the juniper vegetation type, followed by shadscale, greasewood, and riparian; however, the results from a separate pilot study for a lizard capture-recapture program suggested

TABLE IV-28

AMPHIBIAN AND REPTILE
SPECIES LIST FROM OBSERVATIONS ON OR WITHIN 1.6 KM (1 MILE) OF UTAH OIL SHALE TRACTS, DECEMBER 1974 THROUGH OCTOBER 1975

X = observed, G = greasewood, J = juniper, S = shadscale, R = riparian.

	Date/Vegetation Type																							
	December 1974				February 1975				April 1975				June 1975				August 1975				October 1975			
Order/Species	G	J	S	R	G	J	S	R	G	J	S	R	G	J	S	R	G	J	S	R	G	J	S	R
Salientia																								
Great Basin Spadefoot	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-
Woodhouse's Toad	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-
Chorus Frog	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	?	-	-	-	-	-	-	-	-
Leopard Frog	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-
Squamata																								
Eastern Fence Lizard	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	X	X	-	X	-	X
Sagebrush Lizard	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	X	X	X	X	X	-
Short-horned Lizard	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	X	-	-	-	X	-
Tree Lizard	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	X	X	X	-	X	-	X	-	-
Side-blotched Lizard	-	-	-	-	-	-	-	-	-	X	-	-	X	X	-	-	X	X	X	X	X	X	X	X
Western Whiptail	-	-	-	-	-	-	-	-	-	-	X	X	X	X	-	X	X	X	X	X	-	X	-	-
Racer	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	X	-	-	-	-
Striped Whipsnake	-	-	-	-	-	-	-	-	-	-	-	-	X	-	X	X	X	X	-	X	-	X	X	-
Gopher Snake	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	-	X	X	X	X	-	X
Western Terrestrial Garter Snake	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	X	-	-	-	X
Western Rattlesnake	-	-	-	-	-	-	-	-	-	-	-	-	X	X	-	-	X	X	X	-	X	-	-	-

- indicates no animals were observed during transect walks

TABLE IV-29

AMPHIBIAN AND REPTILE
NUMBERS ACTIVE ABOVEGROUND AS DETERMINED BY FLUSHING TRANSECTS ON 12 SITES IN FOUR VEGETATION TYPES. "BLANKS" INDICATE INSUFFICIENT DATA FOR MEANINGFUL DETERMINATION.

Sampling Site	Species	Date					
		June 1975			August 1975		
		Number Observed	Number per ha	95% Confidence Interval	Number Observed	Number per ha	95% Confidence Interval
Primary Greasewood	Eastern Fence Lizard	1	0.50		-	-	
	Sagebrush Lizard	4	4.00		3	3.00	
	Western Whiptail	3	2.00		-	-	
	Unidentified, Lizard	2	1.00		-	-	
	TOTAL	10	7.50		3	3.00	
Secondary Greasewood	Eastern Fence Lizard	-	-		1	2.00	
	Sagebrush Lizard	12	20.00	9.26-30.74	18	32.00	24.67-39.33
	Side-blotched Lizard	-	-		2	4.00	
	Western Whiptail	4	8.00		4	4.00	
	Striped Whipsnake	-	-		2	4.00	
	TOTAL	16	28.00		27	46.00	
Off-tract Greasewood	Sagebrush Lizard	1	1.00		-	-	
	Side-blotched Lizard	-	-		1	2.00	
	Western Whiptail	3	2.00		1	2.00	
	Western Rattlesnake	2	2.00		-	-	
	Unidentified, Lizard	1	1.00		-	-	
	TOTAL	7	6.00		2	4.00	
Primary Juniper	Eastern Fence Lizard	9	9.00		4	2.00	
	Sagebrush Lizard	19	17.00	7.40-26.60	21	16.00	11.20-20.80
	Tree Lizard	1	1.00		-	-	
	Side-blotched Lizard	1	1.00		9	9.00	
	Western Whiptail	3	1.50		-	-	
	Unidentified, Lizard	2	2.00		-	-	
	TOTAL	35	31.50		34	27.00	
Secondary Juniper	Eastern Fence Lizard	1	1.00		-	-	
	Sagebrush Lizard	7	10.00		12	24.00	12.24-35.76
	Side-blotched Lizard	2	2.00		3	6.00	

TABLE IV-29 (cont.)

Sampling Site	Species	June 1975 Number Observed	June 1975 Number per ha	June 1975 95% Confidence Interval	August 1975 Number Observed	August 1975 Number per ha	August 1975 95% Confidential Interval
Secondary Juniper (continued)	Western Whiptail	2	0.80		2	2.00	
	Unidentified, Lizard	2	1.00		-	-	
	TOTAL	14	14.80		17	32.00	
Off-tract Juniper	Eastern Fence Lizard	1	0.67		-	-	
	Sagebrush Lizard	2	4.00		6	12.00	
	Side-blotched Lizard	1	2.00		1	2.00	
	Western Whiptail	3	6.00		5	10.00	
	Unidentified, Lizard	1	1.00		1	2.00	
	TOTAL	8	13.67		13	26.00	
Primary Shadscale	Eastern Fence Lizard	-	-		1	0.25	
	Sagebrush Lizard	12	20.00	0-30.41	15	9.67	3.18-16.15
	Short-horned Lizard	4	6.67		2	1.00	
	Side-blotched Lizard	-	-		3	1.00	
	Unidentified, Lizard	1	1.67		4	2.00	
	TOTAL	17	28.34		25	13.92	
Secondary Shadscale	Sagebrush Lizard	1	3.33		5	8.00	
	Short-horned Lizard	2	6.67		1	2.00	
	Side-blotched Lizard	-	-		2	2.00	
	Unidentified, Lizard	-	-		2	4.00	
	TOTAL	3	10.00		10	16.00	
Off-tract Shadscale	Sagebrush Lizard	8	13.33		14	28.00	15.00-41.00
	Unidentified, Lizard	1	3.33		1	2.00	
	TOTAL	9	16.66		15	30.00	

TABLE IV-29 (cont.)

Sampling Site	Species	Date June 1975 Number Observed	Number per ha	95% Confidence Interval	August 1975 Number Observed	Number per ha	95% Confidence Interval
Primary Riparian	Leopard Frog	-	-		1	2.00	
	Eastern Fence Lizard	1	0.67		1	-	
	Sagebrush Lizard	-	-		1	2.00	
	Side-blotched Lizard	-	-		2	4.00	
	Western Whiptail	-	-		1	2.00	
	Racer	2	2.00		1	2.00	
	Striped Whipsnake	-	-		1	2.00	
	Gopher Snake	1	2.00		1	2.00	
	Western Terrestrial Garter Snake	-	-		2	1.33	
	Unidentified, Lizard	-	-		2	1.33	
	TOTAL	4	4.67		12	18.66	
Off-tract Riparian	Eastern Fence Lizard	4	6.00		3	2.00	
	Sagebrush Lizard	1	2.00		4	8.00	
	Western Whiptail	3	4.00		3	4.00	
	Racer	1	1.00		-	-	
	TOTAL	9	13.00		10	14.00	
Riparian Greasewood	Eastern Fence Lizard	-	-		1	2.00	
	Sagebrush Lizard	11	23.33	16.80-29.87	4	6.00	
	Unidentified, Lizard	3	3.33		-	-	
--------	TOTAL	14	26.66		5	8.00	

that lizards may be the most abundant in the shadscale vegetation type. The most abundant species reported on the transects in all vegetation types was the sagebrush lizard. During June and August, the combined estimated numbers per ha of sagebrush lizards and side-blotched lizards were as high as 20.00 and 36.00 in the greasewood vegetation type; 18.00 and 30.00 in juniper; 20.00 and 28.00 in shadscale; and 23.33 and 8.00 in riparian, respectively.

Snakes were observed on the tracts from June through October. Two snake species, the striped whipsnake and the gopher snake, were noted in all four major vegetation types; whereas two others, the racer and the western terrestrial garter snake, were seen only in riparian habitat. Western rattlesnakes usually were found in the greasewood vegetation type. A few snakes representing several species were recorded on amphibian and reptile transect walks in June and August, primarily on the riparian sampling sites along the White River (Table IV-29). During non-scheduled snake sampling, the species most commonly seen was the gopher snake, followed by the western rattlesnake and the striped whipsnake.

Discussion

The number of amphibian and reptile species observed on the tracts was greater during summer than in spring or fall because amphibians and reptiles were most active during the warmest part of the year. All species hibernated during the winter. In June and August, a greater number of species were recorded in the riparian vegetation type than in the other types. This is because amphibians and some species of snakes appeared to be confined to riparian areas, whereas most reptiles use other vegetation types in addition to the riparian type. The absence of amphibians outside of the riparian community was not surprising, since the landform of the tracts precludes extensive pool formation during summer thundershowers.

The total population densities of amphibians and reptiles aboveground, estimated from data collected during transect walks, were greatest in the juniper and shadscale vegetation types and least in the riparian. Although amphibians and snakes were seen entirely or primarily on the riparian sampling sites, these groups accounted for only a small proportion of all transect observations. Ninety-six percent of the amphibians and reptiles recorded on transect walks in June and August were lizards.

It must be emphasized that the estimates of amphibian and reptile population densities shown in Table IV-29 refer only to the portions of the populations that were aboveground when transect data were collected. Unknown numbers of amphibians and reptiles were inactive and hidden from view when the transects were walked. Thus, the figures given could be low estimates of the total population densities.

2. SPECIAL STUDIES

a. Mule Deer

Objectives

Mule deer are the most common and important big game species in the project area. This study was undertaken to determine population estimates, seasonal activities, use areas, migration patterns, and importance of mule deer as a game species.

Methodology

The number of deer and the areas of use in the project area were determined by a helicopter flight in February 1975. Traps placed during the following weeks in use areas to capture deer for collaring were unsuccessful. Helicopter flights were again conducted in May to determine numbers of deer and to immobilize deer for collaring. A Cap-chur gun and tranquilizer darts were used to immobilize the deer, and color-coded radio transmitting collars were attached to the captured deer. The deer were tracked by radio on a regular basis from May through December. During hunting season (October 18 to 28) a check station was established at the Ignacio Stage Stop to monitor deer kill and interview hunters. Two more helicopter flights were conducted December 15 and 16, 1975, to determine numbers of deer and areas of use and to capture and collar additional deer. The methodology is discussed in detail in the Partial Exploration Plan.

Summary of Results

During the February helicopter flight, a total of 20 deer were seen--3 along the White River near Station S-4 and 17 in the breaks above Hells Hole Canyon. At that time, sheep on the tracts were using most of the area from Evacuation Creek to Asphalt Wash. Subsequent attempts to trap these deer for collaring were unsuccessful because the sheep consumed the bait and sprang the traps; relocated traps were also unsuccessful.

From February through April, deer were observed in small bands scattered throughout the tracts. On April 22 most of the sheep had left the tracts, and deer began appearing more frequently and in larger numbers. By May 1, it was determined that there were enough deer on the tracts to warrant resumption of the capture program. It was estimated that between 50 and 75 deer were present on the project area, all either in the White River riparian area or in the immediately adjacent uplands.

Seven deer were captured and collared during May. Each was fitted with a radio transmitting collar and color-coded neckband for identification by people not directly associated with the program (Figures IV-14 and IV-15).

During summer, only six of these animals were monitored on a regular basis because the seventh was never located after capture and release. Little movement of the six animals observed was noted. Home ranges appeared to center around the areas along the White River where each deer was first observed after capture (Figure IV-16). This pattern was broken for only short periods during summer when deer could not be located, but would reappear a day or two later in the same area. During this period, increasing deer movements were observed in the side canyons leading away from the river. In these side canyons radio signals are very poor making if difficult to monitor movements. Uncollared deer were observed lying in the shade under ledges in the broken areas and side canyons adjacent to the river.

Movements up the side canyons appears to be related to high temperatures and increased insect activity during the day. Observations indicated that the deer would move to the cooler shaded areas early in the day and remain until evening when temperatures dropped. At that time the deer would return to the river bottom to obtain water and food.

During the moderate temperatures in September the collared deer began expanding their range and on numerous occasions could not be located in areas they had frequented during

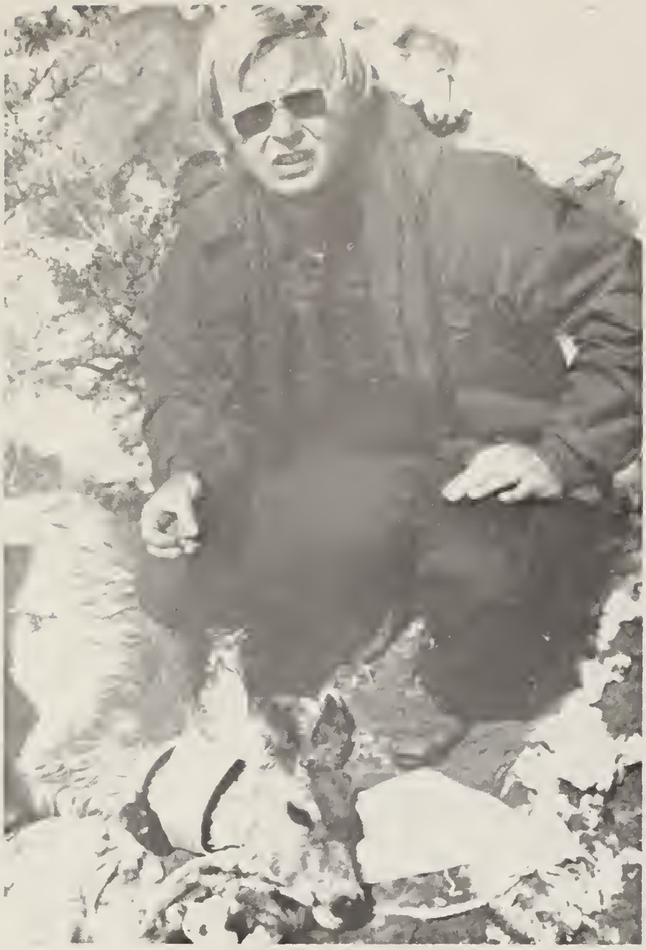
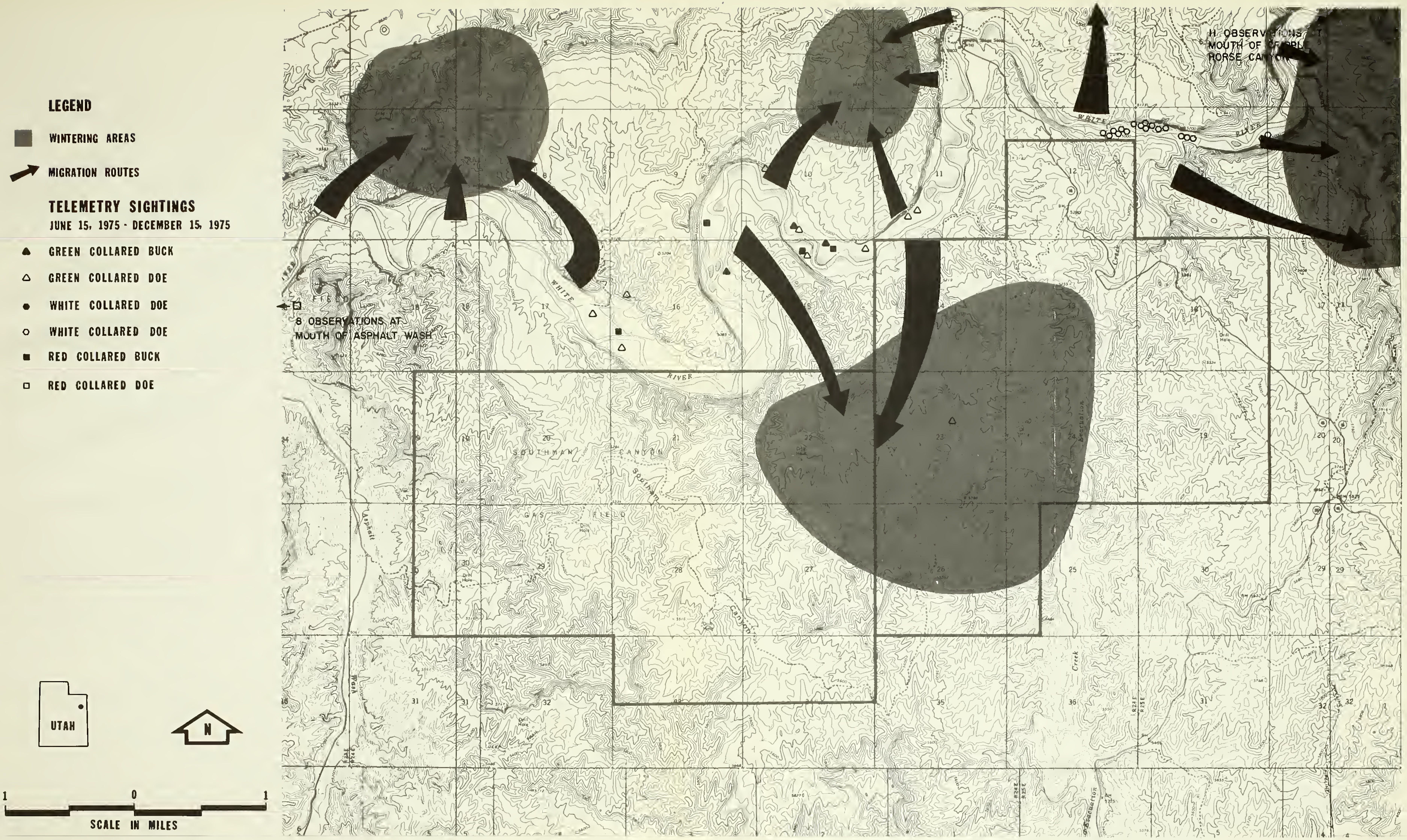


FIGURE IV-14 RADIO AND COLOR BANDING OF TRANQUILIZED DEER BY UTAH DIVISION OF WILDLIFE RESOURCES.

FIGURE IV-15 BANDED DEER - EVACUATION CREEK.



DEER MIGRATION ROUTES, WINTERING AREAS, AND TELEMETRY SIGHTINGS

FIGURE IV-16

summer. The canyons adjacent to the river were scanned, but poor radio signals in the extremely broken and rough terrain limited observations. Observations during this period indicated the deer were probably utilizing areas of better browse availability returning to the river only for water at night. Three collared deer were successfully located early in September when they returned to the riparian areas.

During the latter part of September and early October the radio receiving unit had to be returned for repairs, and therefore no radio monitoring was conducted during this time; however, field observations indicated that a large population of deer was still resident along the White River and in the side canyons and on the benches. Radio tracking was resumed during October, and four collared deer were located in their home areas.

Interviews with deer hunters during the deer hunt (October 18 to 28) offered additional information on collared deer. A green-collared deer was observed October 18 on the uplands 1.8 km (1.1 mi) north of Station X-2. A red-collared deer was observed 0.4 km (0.25 mi) upstream from Station S-13 on the White River. A drug dart that had failed to function after injection into an animal in early May at the mouth of Hells Hole Canyon was recovered from the flank of a buck deer killed by a hunter 180 m (600 ft) downstream from the mouth of Hells Hole Canyon. Although this does not indicate the animal's movements between early May and late October, it is significant that the animal, at least at the time of kill, was only a short distance from where it was observed almost seven months before. Interviews with hunters during late October indicated a large deer population along the White River and adjacent areas and extending up Evacuation Creek to Stations G-14 and G-18. Because of the inability of hunters to remember what animals they had seen (i.e. does, fawns, bucks, sex, age ratio, etc.) where and when and their inability at identifying on a map where they had harvested an animal no attempt was made to compile data on these observations.

During November, the four collared does were monitored successfully. Again, activity was consistently in the White River riparian area. In almost all instances, each deer could be located easily in its home range area at any time. The two collared bucks were not located and have not been located to date.

In an effort to determine where these two animals had moved tracking was attempted using the airplane. The area was intensively covered as far south as the Bookcliffs with no observations. Contacts with hunters indicate that one buck may have been shot (Red collar) near the mouth of Southam

Canyon. However, the hunter who may have shot the deer refused to admit that he shot the animal. It is assumed that the individual felt he may be penalized if he admitted he shot the deer.

After the storms and cold of December, an aerial trend-count was completed by helicopter December 15 and 16 in which 152 deer were observed in the project area (see Table IV-30). As shown in Table IV-30, there was an average of 1.4 deer per km^2 (3.7 deer per mi^2), based on the total project area (10,529 ha [26,018A]); however, there are areas of the tracts the deer never use (monoliths, etc.) and other areas such as the riparian areas, benches and canyon bottoms where browse availability is good where they concentrate. As a result, there are no ways to determine highs and lows in population numbers between the various portions of the study area.

Deer movement to higher areas was very pronounced with the onset of cold winter temperature inversions on the White River. Deer were numerous in the riparian area around Hells Hole Canyon and in the breaks above the canyon, but they became increasingly scarce as the count continued downstream. All but six deer observed below Iganico bridge were in the broken upland and juniper areas well above the river. In numerous instances, old deer tracks in the snow were found on the riparian area leading to higher areas away from the river, where the deer would be located.

Data on temperatures in the study area show a direct relationship between temperature inversions in the river bottom and deer movements to higher areas. The deer moved from the river bottom to the concentration areas shown in Figure IV-16. The temperature differential during some periods approached 20 degrees. Discussions with field personnel indicate that this is a common phenomena that has been occurring for as long as anyone can remember. From the data it appears that a drop of 5 or more degrees will motivate the deer to move. The animals will then move up to the benches and onto the south facing exposures. Observations indicate they prefer to stay in these areas until temperatures along the river bottom rise.

As an indicator of deer productivity in the tract area, observations of does and fawns were recorded during September, October, and early November. A total of 116 deer were classified in determining a fawn:doe ratio for the project area. The estimated production for 1975 was 81 fawns per 100 does, or 81 percent.

TABLE IV-30

DECEMBER DEER TREND COUNT
OIL SHALE TRACTS U-a AND U-b

Location	Number of Deer
Hells Hole Canyon (uplands and river)	68
A-7 (north of White River and U-b) to Igancio Stage Stop	8
Evacuation Pipeline (river)	12
Ignacio Stage Stop to A-3 (north of White River and U-a)	20
A-3 to Asphalt Wash	16
Evacuation Creek	10
A-11 (southwest U-b)	12
X-4 (northwest U-b)	6
Total Deer:	152

Total Area Surveyed: 10,529 ha (26,018 ac)
105.4 sq km (40.7 sq mi)

Density: 0.01 deer/ha
(0.006 deer/acre)
1.4 deer/sq km
(3.7 deer/sq mi)

Following is a breakdown of all deer classified during this period.

64	Does
52	Fawns
3	Bucks
119	Total

These were random observations made during the months indicated. All data are from periodic reports.

During the 1975 deer hunt in Utah, a check station was set up at Ignacio to monitor deer kill and hunter success in the project area, and the same data was obtained for the remainder of deer herd unit 28A (Utah DWR designation for other management unit encompassing the tracts). The following tabulations are from the check station and from field checks of hunters.

	Hunters	Deer	Success
28A (excluding Tracts U-a and U-b)	140	19	13.6%
Tracts U-a and U-b	58	8	13.8%
Combined	198	27	13.6%

Three additional deer were taken after the opening weekend, one of which was not examined firsthand. The ten deer examined were aged using the tooth replacement and wear method. The age breakdown is contained in Table IV-31.

Discussion

Radio tracking and field observations indicate that the deer use the riparian area along the White River from late spring through late fall.

As shown in Figure IV-16 the deer remained in the river bottom the majority of time. In addition the animals were, for the most part, very restricted in their movements. Some of the collared deer never traveled over 0.4 to 0.8 km (0.25 to 0.5 mi) in any given day. Observations in the summer indicate that the deer tend to leave the river to escape the heat and insects during the day returning in the evening for water and food. The heavy dependence of deer on the riparian area

TABLE IV-31

DEER HARVEST STRUCTURE
OIL SHALE TRACTS U-a AND U-b
1975

Age Class	Number
Yearling	6
2 1/2 year old	1
Mature (over 2 1/2)	3
Total	10

can be correlated with three factors, all related to the peculiarities of this habitat type:

a. Cover: Observations indicate that deer actively seek out the densely vegetated riparian area for escape cover and for fawning.

b. Water: The White River is the only reliable water source for most of this area.

c. Food: The riparian area with its deep soils and abundant water supply, produces more of certain types of forage than do the dry upland areas. This is undoubtedly even more important during spring and early summer, when does are nursing fawns and require succulent forbs and other vegetation for milk production.

With the onset of colder weather, the deer migrate to the broken upland and juniper areas well above the river. During the period of sheep grazing from December through April, only a few deer were observed in small bands scattered throughout the tracts. With the cessation of grazing in April, more deer were observed on the tracts, which indicates that during the sheep grazing period, many deer leave the project area and the remaining deer scatter in small bands. The deer move into those areas such as Hells Hole Canyon where browse is available and no sheep are present.

Observations indicate the deer move out of smelling range. The distance the deer move from the sheep depends upon the prevailing winds. Normally a deer can smell sheep for 2-3 km and will move at least that far from the sheep.

From observations of does and fawns recorded during September, October, and early November, the fawn:doe ratio was determined to be 81 fawns per 100 does, which is considered very good production for the type of habitat found in the project area.

b. Predators

Objectives

Three predator species have been selected as the focus of this study: coyotes, bobcats, and mountain lions. Coyotes are considered one of the most common and economically important predators in the West. Coyotes eat sheep (Davenport et al. 1973), and they may be responsible for as much as 4 percent of the approximately 10 percent of sheep lost every year (Wagner 1972).

Personnel of the Utah Division of Wildlife Resources (DWR) have indicated that bobcats are at a low level in northeastern Utah. This decline has been attributed to the following:

a. Heavy trapping because of extremely high fur prices

b. Increased accessibility of remote areas by four-wheel drive vehicles and snowmobiles

c. Relative ease with which even novice trappers can catch bobcats

d. Stockmen hiring trappers to eliminate animals even in summer, when pelts are worthless

The Utah DWR believes that this region-wide decline pertains to the project area also. At this time, no protective regulations have been impelemented. Thus, the local bobcat population is not expected to increase in the near future.

Mountain lions are common and widespread on the East Tavaputs Plateau. Their primary range is south of the project area; however, during the winter, they are known to occupy the project area (Olsen 1973).

The objectives of this study are to determine population estimates, activities, and importance of coyotes and to determine the presence and use areas of bobcats and mountain lions in the project area.

Methodology

The sources of information about coyotes were a U.S. Fish and Wildlife Service scent-post transect near the tracts, professional trappers and sheepherders that used the tracts, and a trapline maintained on the tracts.

Scent Transect No. 5, operated by the U.S. Fish and Wildlife Service, runs from a point near Bonanza 24 km (15 mi) north toward Dinosaur. The transect consists of 50 stations placed about 0.5 km (0.3 mi) apart. At each station a scent attractant was placed in the center of a patch of smoothed base ground. The ground was checked daily for coyote tracks for five days.

A leg-hold trapline was maintained between late summer and fall to capture coyotes and bobcats for collaring. A professional trapper familiar with the project area was contracted to locate coyote dens on the project area. Shepherds and professional trappers in the region were interviewed. The methodology is discussed in detail in the Partial Exploration Plan.

Summary of Results

In 1974, the latest year for which figures were available, Scent Transect No. 5 had a density index of 7 (Roughton 1974). This meant that 0.007 coyotes visited the scent-post per night.

A total of four coyotes were captured in July. One, a male pup, was collared with a radio transmitter. The animal was successfully monitored on two subsequent days (two and four days later), each time farther south in Asphalt Wash. Attempts to locate the animal on later occasions were unsuccessful. Three additional pup coyotes were captured (two males and one female), but they were too small to be fitted with collars.

Two days were spent on the project area with a professional trapper familiar with the area in an attempt to locate coyote dens. Although signs indicated the possibility of dens in Southam Canyon and Asphalt Wash, no dens were found.

During the summer of 1974, the trapper (employed by a sheep rancher) found and destroyed seven dens of coyotes from Evacuation Creek bridge to Asphalt Wash. This individual and another professional trapper had also trapped a minimum of 50 coyotes from Hells Hole Canyon to Asphalt Wash in fall 1974 while employed by a sheep permittee on the area. Coyotes were also subjected to aerial shooting contracted by the Fish and Wildlife Service during late 1974 and early 1975. Estimates are that seven coyotes were killed on or near the project area during the flights.

Sheepherders in the area stated that sheep losses to coyotes were high, especially on the lambing grounds north of the White River.

There is a strong indication that breeding animals were largely eliminated from the area by these activities during the 1974-1975 period. During summer 1975, no denning was known to have occurred. As of December 31, no professional trappers are known to have operated in the project area.

With a reduced mortality in 1975-76, populations may build to numbers sufficient to allow trapping and radio collaring.

Bobcat sign was very scarce throughout 1975. Two bobcats were observed during the year by VTN personnel. A weak, emaciated kitten, probably an orphaned animal, was found near the Evacuation Creek bridge after the 1975 Utah deer hunt. A water monitoring technician released a mature bobcat which was caught in a private trappers leg-hold trap in Asphalt Wash on November 2. At that time, the technician was not aware of the telemetry program. All personnel involved with the baseline data collection program have since been instructed to not release captured animals, but report the capture to the Utah DWR immediately.

There was no sign of mountain lions throughout 1975.

Discussion

The data from scent-post transects are only a rough index of the coyote density. However, if the index of 7 reflected the relative number of coyotes in the area of the tracts, the density was low. Areas in Texas yield index figures of 20 times higher than that of the Bonanza transect. Based on density estimated and index figures elsewhere in Utah, an estimate of about 0.1 coyotes per sq km (0.04 coyotes per sq mi) on the tracts is reasonable.

The number of predators in an area does not indicate the impact of predators on a prey species. Thus, the low estimate of coyote populations on the tracts is not necessarily inconsistent with the reported high sheep losses.

Bobcat populations in the project area are believed to be at an extremely low level at this time.

c. Amphibians and Reptiles

Objectives

The amphibian and reptile study was conducted to determine the species inhabiting the project area, the relative abundance and distribution of each species in each of the four major vegetation types, and the relationships between reptiles and vegetation, lizards and snakes, and snakes and rodents. In addition, the study was conducted to integrate these findings with the general sampling data and pertinent literature.

Methodology

Amphibians were collected in the riparian areas along the White River during May, June, and July 1975. Animals were captured by hand or hand net, identified, and released. Larval-count estimates, times of metamorphoses and emergence, and times of emergence and burrowing of adults were recorded as site visits permitted.

Lizards were captured during daily walks through a measured plot in each vegetation type (see Table IV-32). The study plots were situated near vegetation sampling sites. The lizards were captured by a slip-knotted noose on the end of a pole and were toe-clipped for subsequent identification. Walk-through times were varied for a random sampling approach for species known to have different activity periods.

Snakes were observed during the amphibian and lizard studies. In addition, night "road runs" were conducted because snakes are easily seen on roads. Other field biologists working on the tracts have been field-trained to identify the snake species they observe, and their observations are included in this report. All nomenclature follows Stebbins (1966).

Summary of Results

Amphibians: Amphibians on the two tracts are restricted to the riparian vegetation along the White River and are active from May through September. No amphibians have been found at gas-well water ponds south of Tract U-a or in Asphalt Wash or Evacuation Creek during flow events. Since the landform of the tracts precludes extensive pool formation during summer thundershowers the absence of amphibians outside the riparian community is not suprising.

Three amphibian species have been observed along the White River since June 1974. The leopard frog (Rana pipiens) is the most common species. During summer 1975, 57 leopard frogs were observed in a single basin directly west of Ignacio Stage Stop near the Bonanza pump station. In June 1975 this basin was almost dry, but in July it contained nearly 1.2 m (4 ft) of water. In July, the basin contained four adult leopard frogs, several thousand leopard frog tadpoles, several thousand Great Basin spadefoot toad tadpoles, (Scaphiopus intermontanus), a wandering garter snake (Thamnophis elegans vagrans), and many aquatic invertebrates. By August the pool was drying up, and only a few adult and many juvenile frogs were present. Spadefoot toad tadpoles

TABLE IV-32

1975 LIZARD SAMPLING EFFORT AND PLOT SIZE

	Riparian	Sagebrush-Greasewood	Shadscale	Juniper
Total 1975 Lizard Collection Time	6 hr. 40 min.	7 hr. 15 min.	8 hr. 25 min.	7 hr. 10 min.
Sampling Plot Size	1.4 Hectares (3.5 acres)	2.6 hectares (6.4 acres)	1.1 hectares (2.7 acres)	2.4 hectares (5.9 acres)

were not present, it is assumed they metamorphosed and left the area.

The rocky mountain toad (Bufo woodhousei) was seen infrequently along the White River. Only four individuals were observed: two in June 1974 at S-4 and S-13, and two in August 1975. One August sighting was directly across the river from Ignacio Stage Stop and the other was on the east-west line of WR2 (see Figure IV-17).

Lizards: Reptiles were seen in all four vegetation communities in the project area and were active from April into October. The maximum number of animals sighted during June, July, and August 1975 are shown in Table IV-33. No correlation was found between the number of observations and the time required to make them (Tables IV-32 and IV-33). The number of recaptures was too small to make reliable population estimates. Locations of the sample plots are shown in Figure IV-17.

Snakes: Snakes were seen in all four vegetation communities of the White River region. Observations were made by diurnal and nocturnal road runs in June and August 1974 and June, July, and August 1975 (Figure IV-17).

Seven species of snakes probably inhabit the area. As of October 1975, five species have been observed within the 1.6 km (1-mi) perimeter around the lease tracts. The plateau night snake (Hypsiglena torquata), possibly the rarest serpentine inhabitant of the region, and the milk snake (Lampropeltis triangulum taylori) probably inhabit the site but have not been observed there. The night of June 1, 1975, a milk snake was captured off the site approximately 1 km (0.6 mi) north of the Bonanza field facilities on Highway 45, near Bonanza (Figure IV-18).

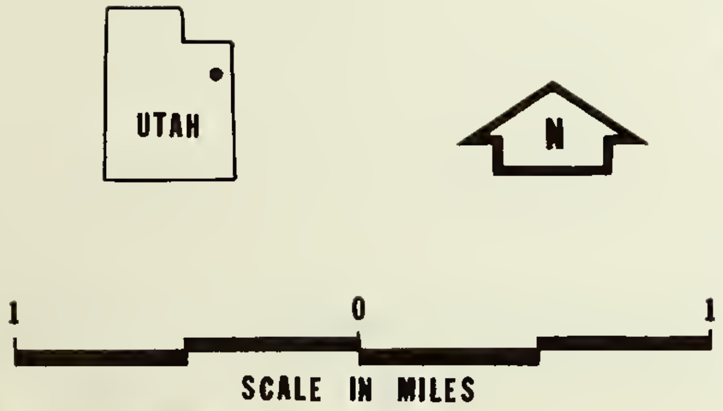
All verified snake observations through October 1975 are shown in Figure IV-17. Table IV-34 gives the number of each snake species seen in each vegetation type.

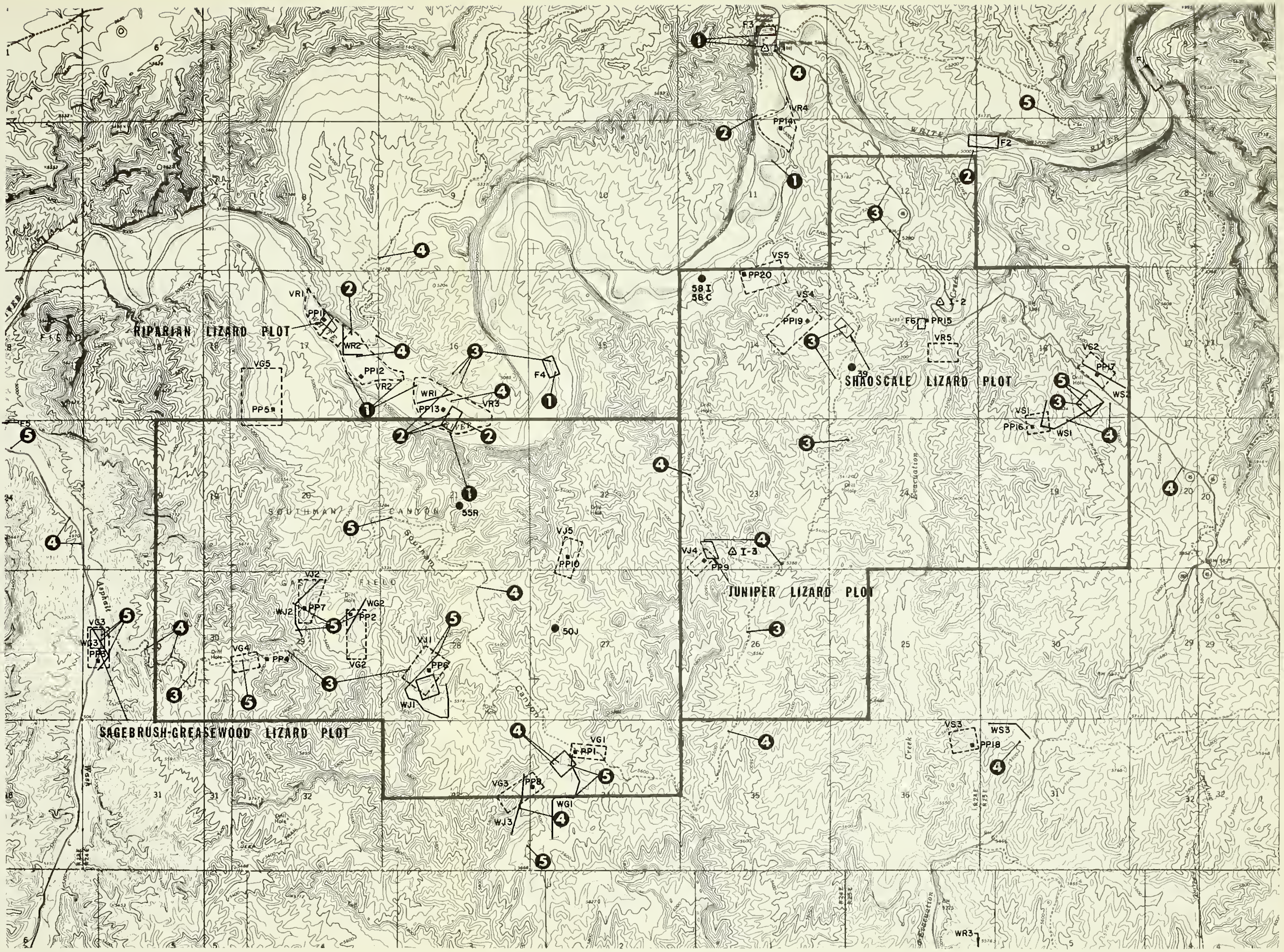
Discussion

Preliminary observations made from analysis of the first year's data include the following:

(1) The only lizard found in all four vegetation communities was the northern side-blotched lizard (Uta stansburiana stansburiana). It was the most abundant lizard on the tracts.

- ● MICROOGANISM SAMPLING STATION
- △ INVERTEBRATE SAMPLING STATION
- —— W WILDLIFE SAMPLING AREA
- [- - -] V VEGETATION STUDY AREA
  - G GREASEWOOD
  - J JUNIPER
  - R RIPARIAN
  - S SHADSCALE
- ▭ F AQUATIC BIOLOGY SAMPLING STATION
- ▪ PP PHOTO PLOT
- ❶ WANDERING GARTER SNAKE
- ❷ WESTERN YELLOW-BELLIED RACER
- ❸ DESERT STRIPED WHIPSNAKE
- ❹ GREAT BASIN GOPHER SNAKE
- ❺ MIDGET FADED RATTLESNAKE





SITE MAP - LIZARD PLOTS & SNAKE OBSERVATIONS

FIGURE IV-17

TABLE IV-33

TOTAL NUMBER OF LIZARDS OBSERVED IN EACH VEGETATION PLOT AND SPECIES DIVERSITY*

Species	Common Name	Riparian	Sagebrush-Greasewood	Shadscale	Juniper	Totals
Sceloporous undulatus elongatus	Northern Plateau Lizard	10	0	11	2	23
Sceloporous graciosus graciosus	Northern Sagebrush Lizard	0	0	16	8	24
Uta stansburiana stansburiana	Northern Side-blotched Lizard	3	3	10	16	32
Phrynosoma douglassi	Short-horned Lizard	0	0	2	0	2
Cnedmidophorous tigris	Western Whiptail	1	6	8	2	17
Urosaurus ornatus	Tree Lizard	8	0	1	0	9
Totals		22	9	48	28	107
Shannon-Wiener Diversity Index		1.64	0.92	2.23	1.52	2.31

*Numbers represent either the number of toe-clipped animals or the greatest number of observations made during one day, which ever is greater.

TABLE IV-34

NUMBERS OF SNAKES OBSERVED IN EACH VEGETATION TYPE AND SPECIES DIVERSITY

Species	Common Name	Riparian	Sagebrush-Greasewood	Shadscale	Juniper	Totals
Thamnophis elegans vagrans	Wandering Garter Snake	8	0	0	0	8
Coluber constrictor mormon	Western Yellow-bellied Racer	7	0	0	0	7
Masticophis taeniatus taeniatus	Desert Striped Whipsnake	2	3	6	3	14
Pituophis melanoleucus deserticola	Great Basin Gopher Snake	3	8	7	3	21
Hypsiglena torquata loreala	Mesa Verde Night Snake	0	0	0	0	0
Crotalus viridis concolor	Midget Faded Rattlesnake	0	11	3	4	18
Lampropeltis triangulum taylori	Milk Snake	0	1*	0	0	1*
TOTAL SNAKES		20	22	16	10	68
Shannon-Wiener Diversity Index		1.80	1.42	1.51	1.57	2.20

*Captured outside of study area not included in totals, see text

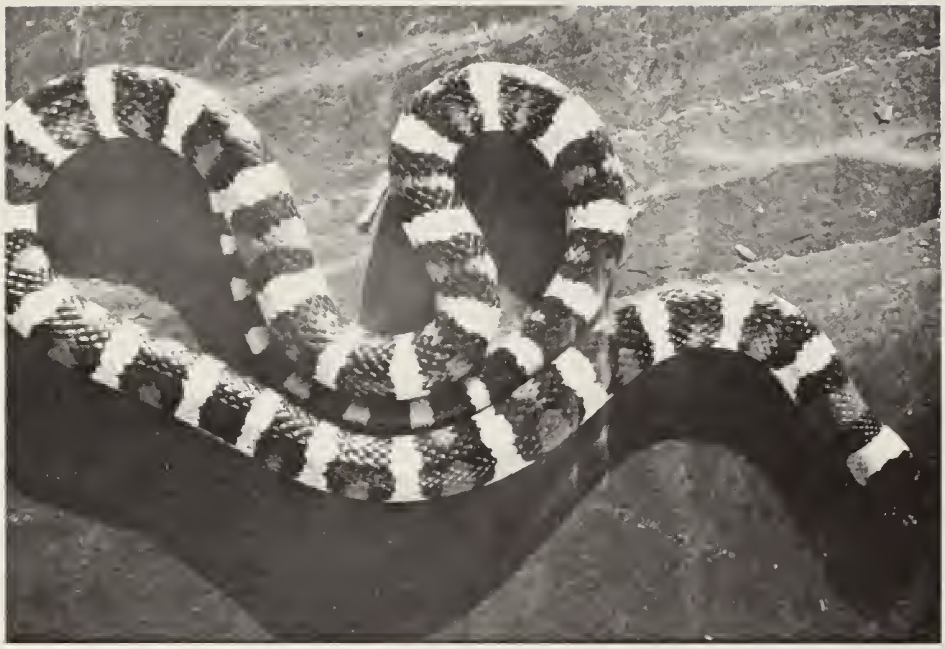


FIGURE IV-18 MILK SNAKE (LAMPROPELTIS TRIANGULUM TAYLORI) . PROBABLY A RARE RESIDENT OF THE TRACTS.

(2) The most abundant lizard within a vegetation type was the northern sagebrush lizard (*Sceloporous graciosus graciosus*) in the shadscale community.

(3) Northern plateau lizards (*Sceloporous undulatus elongatus*) and tree lizards (*Urosaurus ornatus*) inhabited standing and fallen cottonwood trees in the riparian community.

(4) The northern plateau lizard is also an important member of the shadscale lizard assemblage, but outside the riparian community the tree lizard has been found only on shadscale outcrops.

(5) The distribution of the short-horned lizard (*Phrynosoma douglassi*) appeared to be limited to the shadscale community.

(6) The western whiptail (*Cnemidophorous tigris*), the largest lizard in the area, was seen primarily in the sagebrush-greasewood community and to a lesser extent in the juniper community. Many whiptails were captured in the shadscale near the northern border of the sample plot, where there was a transition from shadscale to greasewood.

(7) It was assumed from visual inspection that the lizard assemblage in any one of these vegetation communities was significantly different from that of any other.

(8) The application of the Shannon-Wiener Diversity Index to the data indicated increasing species diversity in the order sagebrush-greasewood, juniper, riparian, and shadscale.

(9) There were no significant correlations between lizard communities and selected vegetation parameters (Table IV-35).

(10) The western yellow-bellied racer (*Coluber constrictor mormon*) and the wandering garter snake (*Thamnophis elegans vagrans*) appear to be restricted to the riparian community.

(11) The wandering garter snake was sighted more frequently at the shoreline of the White River than on dry land.

TABLE IV-35

CORRELATION COEFFICIENTS BETWEEN SELECTED LIZARD AND VEGETATION PARAMETERS

	Vegetation Species	Litter	Bareground	Grass Production	Forb Production	Total Herbage Production
Lizard Species	0.48	0.00	-0.06	0.21	0.65	0.27
Lizard Abundance	0.42	-0.19	0.13	0.03	0.52	0.08
Lizard Species Diversity	0.42	-0.11	0.05	0.12	0.60	0.18

(12) The desert striped whipsnake (*Masticophis taeniatus taeniatus*) was observed in all four vegetation types but was seen most often in the shadscale habitat.

(13) The gopher snake (*Pituophis melanoleucus deserticola*) and the midget faded rattlesnake (*Crotalus viridis concolor*) were the most commonly observed snakes on the tracts. The gopher snake was seen most frequently in the sagebrush-greasewood and shadscale types, whereas rattlesnakes appeared most often in the sagebrush-greasewood type. Although more rattlesnakes were counted, because they are heard as well as seen, the gopher snake is probably the most common snake on the tracts.

(14) The number of snakes by vegetation type increases in the order juniper, shadscale, riparian, and sagebrush-greasewood. Species diversity is high (2.20). Species diversity by vegetation type is highest in the riparian and about equal in the other vegetation types.

(15) In contrast to the lack of significant correlations between lizard species and vegetation parameters (Table IV-35), there were a number of significant correlations between snake community structure and vegetation parameters (Table IV-36). The number and diversity of snake species in a vegetation type increase as the amount of bare ground decreased (r = 0.99 and 0.97, respectively). The number and diversity of snake species in a vegetation type increased with increasing grass production (r = 0.96 and 0.87, respectively).

(16) There was no significant correlation between the snake community structure and forb production. The correlation between snake species and diversity with total herbage production (r = 0.94 and 0.86, respectively) reflects the importance of grass production.

(17) There were no significant correlations between snake abundance and vegetation parameters, which tends to discount predator-herbivorous prey relationships as an explanation of these correlations; rather, there is increasing species diversity with increasing cover and spatial heterogeneity.

TABLE IV-36

CORRELATION COEFFICIENTS BETWEEN SELECTED SNAKE AND VEGETATION PARAMETERS

	Vegetation Species	Litter	Bareground	Grass Production	Forb Production	Total Herbage Production
Snake Species	0.29	1.00	-0.99	0.96	0.64	0.94
Snake Abundance	0.55	0.35	-0.25	0.42	0.27	0.41
Snake Species Diversity	0.13	-0.27	-0.97	0.87	0.61	0.86

(18) Significant correlations between snake species numbers and lizard species numbers are given in (Table IV-37). These correlations probably express causality since lizards are common food items of gartersnakes, racers, and whipsnakes. Lizards are only occasionally taken by gopher snakes and rattlesnakes (Stebbins 1966), and hence the lack of significant correlations. Although the number of snakes observed in 1974-1975 was small, there was general agreement between the field data and literature.

(19) Significant correlations between snake species numbers and pooled rodent trapping data (from Table IV-25, June and August data) presented in Table IV-38. All five species of snakes observed feed on small mammals (Stebbins 1966), so the correlations probably express causality.

(20) Amphibians apparently are not important in the ecology of the project area. In contrast, reptiles appear to be an important segment of the vertebrate population. The abundance of lizards implies an important function in ecosystem energy transfer. The abundance of snakes, which usually occupy the top predator niche (tertiary consumer), probably reflects a high biological productivity for this area.

d. Raptors

Objectives

The two primary objectives of the raptor study were to determine the number of active eyries (nests) in the project area and each species reproductive success, or the number of fledglings (young with feathers for flight), and to determine the species using the project area and the season of use.

Methodology

Active eyries were counted by helicopter flights in late May and early June. After the eyries were located, they were monitored from the ground to determine the reproductive success. The species list of the raptors in the project area was compiled from observations of the summer and winter aerial flights and opportunistic sightings throughout the year.

TABLE IV-37

SIGNIFICANT CORRELATION COEFFICIENTS BETWEEN NUMBERS OF SNAKES OBSERVED AND NUMBERS OF LIZARDS MARKED IN EACH VEGETATION TYPE

	Northern Plateau Lizard	Northern Sagebrush Lizard	Northern Side-blotched Lizard	Short-horned Lizard	Western Whiptail	Tree Lizard
Wandering Garter Snake	--	--	--	--	--	0.99
Western Yellow-Bellied Racer	--	--	--	--	--	0.99
Desert Striped Whipsnake	--	0.97	--	0.96	0.98	--
Great Basin Gopher Snake	--	--	--	--	--	--
Midget Faded Rattlesnake	--	--	--	--	--	--

--Correlation not significant

TABLE IV-38

SIGNIFICANT CORRELATION COEFFICIENTS BETWEEN NUMBERS OF SNAKES OBSERVED AND NUMBERS OF RODENTS MARKED IN EACH VEGETATION TYPE

	Western Harvest Mouse	Bushytail Woodrat	Whitetail Antelope Squirrel	Golden-mantled Squirrel	Deer Mouse	Colorado Chipmunk	Apache Pocket Mouse	Ord Kangaroo Rat
Wandering Garter Snake	--	1.00	--	--	--	--	--	--
Western Yellow-Bellied Racer	--	1.00	--	--	--	--	--	--
Desert Striped Whipsnake	--	--	--	--	--	--	--	--
Great Basin Gopher Snake	--	--	0.93	--	--	--	--	0.91
Midget Faded Rattlesnake	0.93	--	--	--	--	--	0.99	0.98

--Correlation not significant

Summary of Results

Data compiled during the year included a spring species list, nesting locations, species and success, and a winter species survey. In May 1975, a helicopter was used to locate nest sites, species, and success of nesting raptors on the project area (Table IV-39 and Figure IV-19). During this survey the following raptors were observed:

2	long-eared owls
2	Cooper's hawks
9	kestrels
2	prairie falcons
6	red-tailed hawks
8	golden eagles
5	turkey vultures

In addition, more than 40 inactive golden-eagle eyries were observed on and near the tracts. Most of these were in the cliff areas north of the White River.

An estimate of kestrel nesting success was impossible because their nesting sites are so inconspicuous. Additionally, two pair of Cooper's hawks were observed displaying agressive behavior characteristics of nesting birds. One pair was in the riparian area at Station F-5 and the other 200 m (660 ft) below Ignacio in the riparian area. It was felt that nests were probably in both areas, but they could not be located because of the heavy foliage in the dense cottonwood trees.

A winter survey conducted December 15 and 16, 1975 yielded the following raptor sightings:

9	mature golden eagles
2	immature golden eagles
2	mature bald eagles
1	immature bald eagle
2	marsh hawks
1	prairie falcon
1	rough-legged hawk

TABLE IV-39

RAPTOR REPRODUCTIVE SUCCESS

Species	Young	Location
Red tailed hawk	2	Gas well, Center Fork of Asphalt Wash, Sec. 8 (Cliff)
Red tailed hawk	2	400 meters upriver from Ignacio (Tree)
Golden eagle	1	Cliffs across river from A-1 (west of U-a)
Prairie falcon	4	In nest at A-11 (southwest U-b)
Long eared owl	3	Mouth of Cowboy Canyon (Tree)

SOURCE: VTN and Utah Division of Wildlife Resources

One endangered species of raptor was recorded with the sighting of a peregrine falcon off tract at the mouth of Wagon Hound Canyon, April 23 and 28. This sighting was further validated by a previous sighting by a VTN ornithologist. Other raptors added to the species list during 1975 were the short-eared owl, great horned owl, and sharp-shinned hawk.

Discussion

Observations during the first year of data collection indicate that raptors prefer the cliff areas and large cottonwoods along the White River. The importance of these areas cannot be evaluated from the limited data; however, the large number of inactive golden-eagle eyries indicates that in the past this species has used the area much more than they do now, probably because of the low rabbit population on the tracts and in the region (Jerry Craig, Colorado Division of Wildlife, Pers. Com., June 1975).

The existing data is insufficient for any other conclusions as to raptor use and activities on the tracts. A more complete evaluation will be possible when more data are collected and analyzed.

e. Waterfowl

Objectives

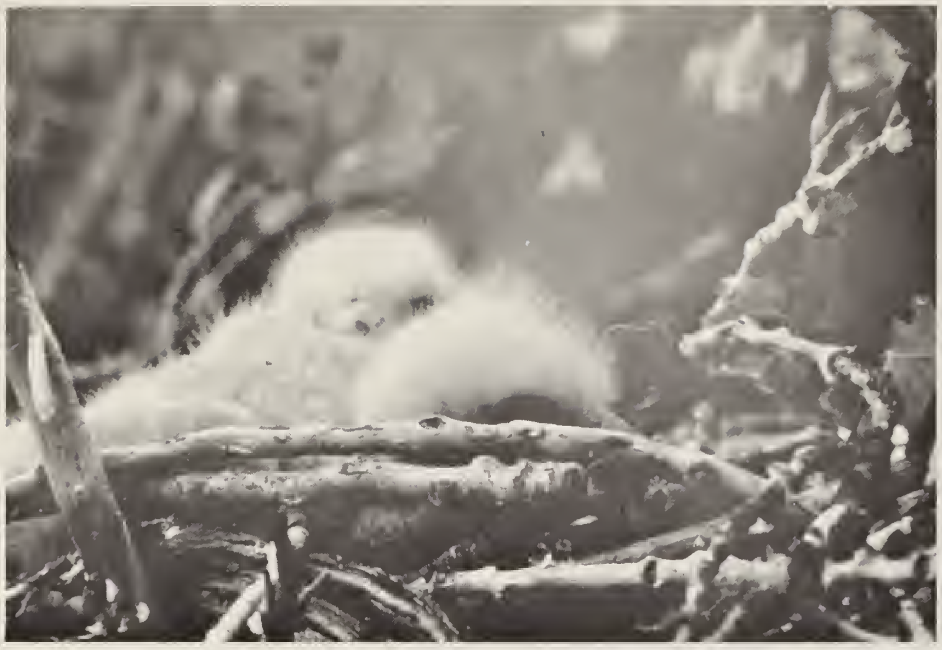
The waterfowl study was initiated to determine what species inhabit the project area and the nesting success of each species.

Methodology

Monthly float trips down the White River were made from March 1975 through September 1975, from Stations S-1 (Hells Hole Canyon) to S-11 (west of Asphalt Wash). These trips were taken to document use and nesting success of waterfowl.

Summary of Results

In early spring through late summer 1975, the White River is



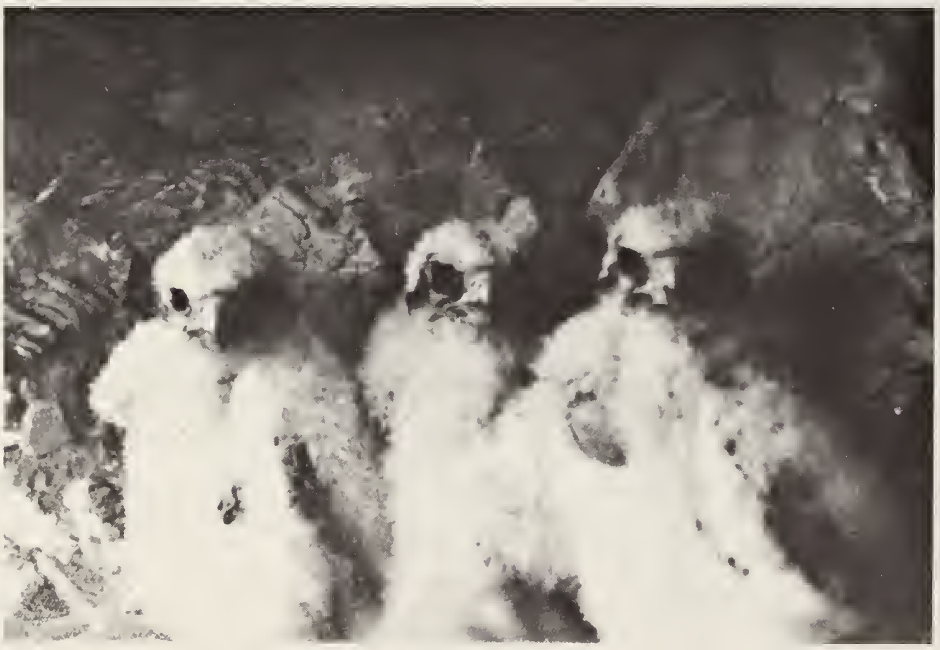


FIGURE IV-19

TOP PHOTO: YOUNG OF RED-TAILED HAWKS (*BUTEO JAMAICENSIS*)

BOTTOM PHOTO: YOUNG OF PRAIRIE FALCONS (*FALCO MEXICANUS*)

used by several species of waterfowl, the most numerous of which are Canada geese. On March 18, eleven pairs and two unpaired Canada geese were observed between Station S-1 and S-11; on April 11, eleven pairs and 6 unpaired birds were present. In July, when nesting activities were completed, 43 birds were observed, including 18 juvenile, 6 paired adults (with young), 8 mixed young and old, 10 unclassified, and one unpaired adult.

Nesting geese were observed using the numerous small islands, mud and sandbars, and debris piles of the White River. The high river banks where grasses, clover (Melilotus) and other forbes were also used for feeding.

Nesting season varied, with the first brood observed May 6, and a brood of 6 small and flightless juveniles was observed July 16. Other juvenile birds observed July 16 were almost full-grown. Average brood size was six juvenile per successful pair. It is assumed that the 10 unclassified birds observed in the July count were unbreeding birds, unsuccessful breeders, and possibly early young indistinquishable from adults.

Maximum population of Canada geese occurred during July when recruitment of juvenile birds was completed. Population density was calculated at 1.5 birds/km (2.4 birds/mile) of river, based on 43 birds on 28.3 km (17.7 miles) of river from S-1 to S-11. Production of young at river nesting sites during this period was calculated to be between a minimum of 0.6 juveniles/km (1.0 juveniles/mile) of river (18 juvenile birds), and 0.8 juvenile/km (1.4 juveniles/mile) of river (24 juvenile birds) maximum density. These figures are based on total length of river including meandering, which is subject to yearly changes. By September, all geese had left the river and none were located on subsequent surveys through November. Figure IV-20 shows seasonal population of Canada geese on the White River.

Other species of waterfowl which occurred intermittently, and for which no estimates of populations could be obtained, were mallard, gadwall, blue and green winged teal, avocets, willets, Wilson snipe, American merganser and great blue heron. No young of any of these species were observed. On October 13, a minimum of 300 sandhill cranes were observed flying south over the project area. There is no evidence that any of these birds landed or attempted to land near the tracts.

Discussion

Canada geese are the primary users of the White River although some use by ducks does occur. Use is limited almost entirely to spring and summer when the significant numbers of geese nest in sandbars and log jams along the river. The birds remain in the area until the goslings are able to fly (late summer) and their food sources (forbes and grasses) along the river banks become depleted or die. Other waterfowl and shore birds nest along the White River, however their numbers are limited.

f. Beaver

Objectives

The beaver study was conducted to determine the role of the beaver in the ecosystem, and to develop an activity intensity index of beavers using the White River.

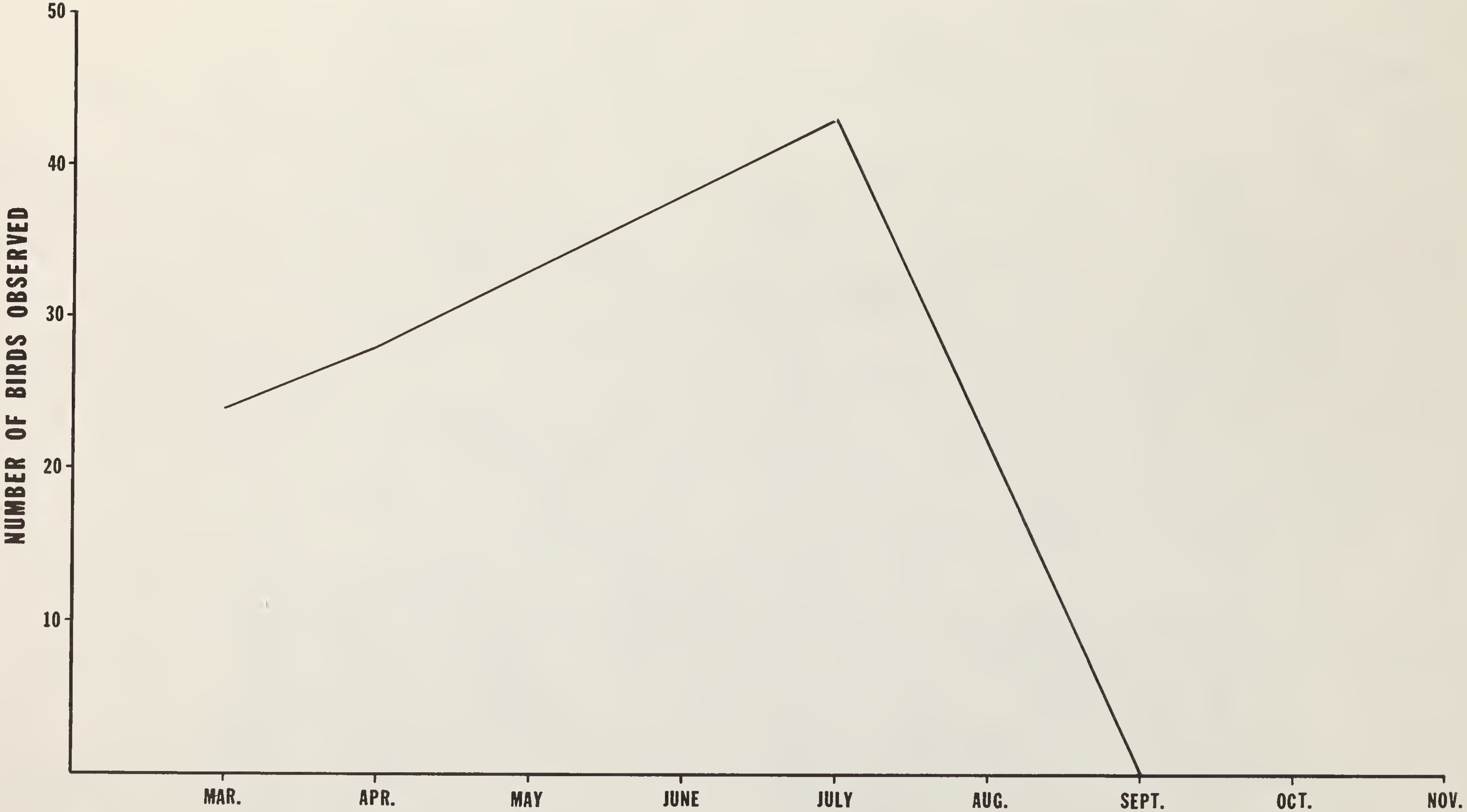
Methodology

Counts of beaver food caches were made during float trips taken in the late fall. The number of caches per kilometer is considered an indicator of activity and population. Although actual population numbers are not obtained from these counts, fluctuations in population size can be determined.

Summary of Results

Bank dwelling beaver are common along the White River in the area of the tracts as indicated by signs of beaver activity from S-1 to S-11. In many sections of the riparian area, beaver have extensively pruned young cottonwood trees, which is their major food source. Some areas are utilized heavily enough to, in effect, manage the cottonwoods for a sapling stage of growth.

The only parameter that was utilized in attempting to derive an index of relative abundance of beavers was a fall count of food caches on the river. This was done by floating the river from S-1 to S-11, and counting all caches that showed indications of being utilized or being actively supplemented in preparation for winter. A total of 57 such caches were observed. Of these, 11 were above Ignacio and 46 were below. This indicated a winter cache concentration of 2.0/km (3.2/mi) of river, as measured along the meanders, from S-1 to S-11.



CANADA GEESE POPULATION ON WHITE RIVER, 1975

FIGURE IV-20

Discussion

Attempts to quantify the beaver on the White River are severely limited by the character of the habitat and of the animal itself. The beaver are entirely bank dwellers, with no evidence of attempted lodge construction anywhere on the river. Location of bank dwellings is also extremely difficult because of fluctuations of the White River and its almost constant state of high turbidity. Also, feeding dens are common, and are easily confused with dwelling dens.

No inferences to actual populations present on the river are implied. However, trends in beaver populations may be indicated by large fluctuations in the number of caches constructed prior to freeze-up of the river in the fall. It would take several years to establish a trend in beaver activity.

g. Livestock

The objective of the livestock study was to integrate Bureau of Land Management (BLM) records of project area grazing into the baseline data. The project area is used for cattle and sheep grazing (Figure IV-21). Sheep use is confined to winter when snow is available in the uplands as a water source. Cattle graze the riparian areas during the summer and fall. Included in Table IV-40 are summaries of all grazing permits on the project area.

Cattle are permitted to graze the riparian area of the White River from Asphalt Wash to Hells Hole Canyon. Approximately 160 head of cattle graze from June 1 to October 31. Total animal units/month (AUM) allowed is 790. Because of the scarcity of water, this use is restricted to the riparian area and those uplands immediately adjacent to it. In 1975, cattle were brought on tract on June 4 and taken off on October 19.

Three permit holders graze sheep on the project area. The earliest permit begins on December 16 and lasts until April 30, for 1800 sheep. Total allowable AUM's is 943. This allotment is restricted to the Southam Canyon area. Between January 1 and April 15, 2650 sheep are permitted on the Hells Hole allotment, from Igancio to Hells Hole, and the uplands south of the river. Total allowable AUM's are 1865. The last unit grazed is the Wagon Hound allotment which allows 2500 sheep from March 15 to April 20, for a total allowable AUM figure of 585. This use is in the area from Evacuation Creek to S-4 (north of U-a).

TABLE IV-40

SHEEP GRAZING LICENSES
ON UTAH TRACTS Ua AND Ub

Nick Theos. Meeker, Colorado
2650 sheep 1-1 to 4-15 97% Free Range (F.R.) Active

Total allowable AUMs - 1865

Tom Theos. Meeker, Colorado
2500 sheep 3-15 to 4-20 72% F.R. Active
2500 sheep 3-15 to 4-20 72% F.R. Non use
3000 sheep 1-1 to 2-26 72% F.R. Non use

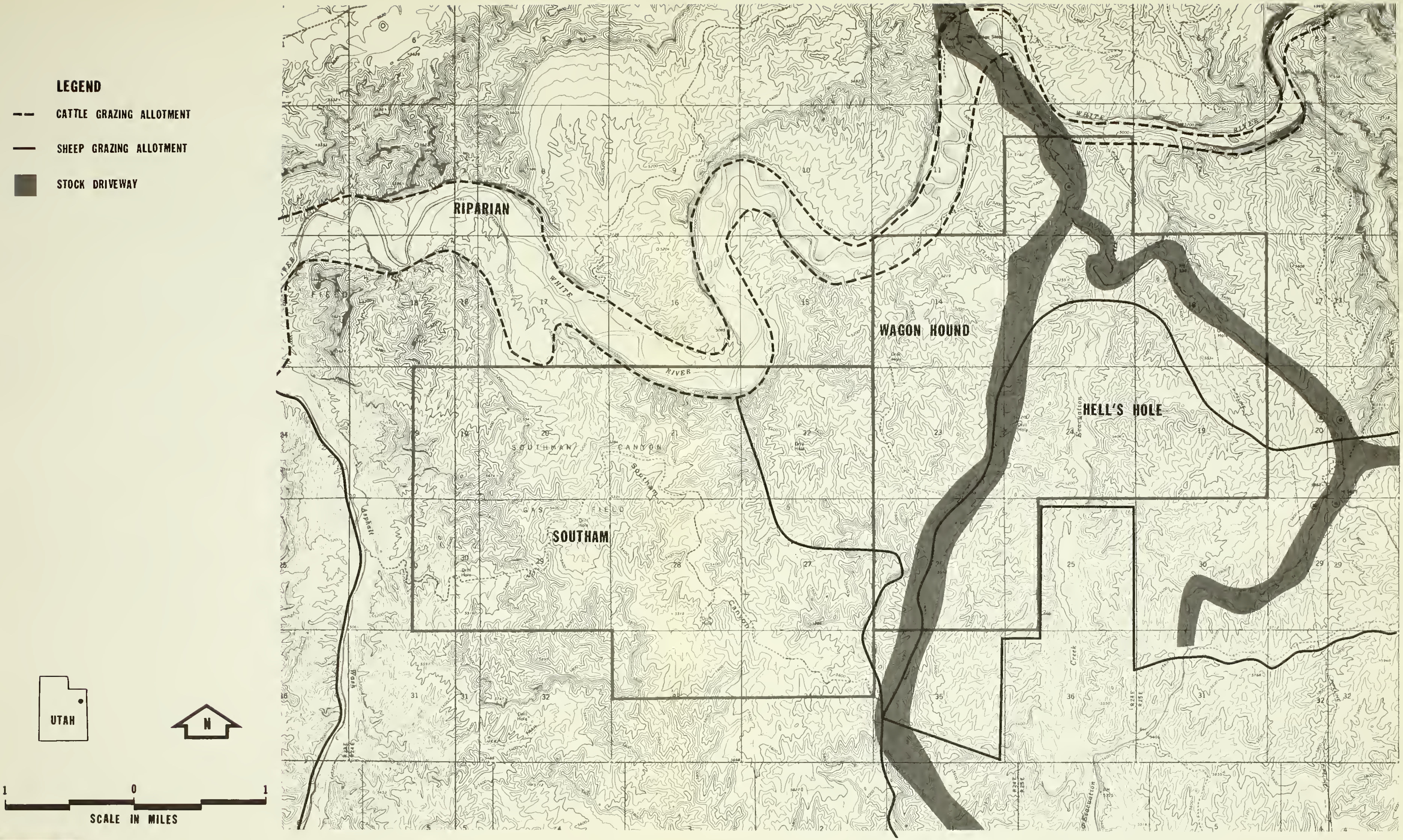
Total allowable AUMs - 1650

Daniel B. and Jerry Carl Seely Meeker, Colorado
1800 sheep - sometime between 12-16
and 4-30 - for approx. 80 days

Total allowable AUMs - 943

NOTE: Not all of this use is on the Tracts.

SOURCE: BLM



BLM GRAZING ALLOTMENTS

FIGURE IV-21

In addition to these allotments, several herds of sheep utilize the stock driveway when going to or from other permit areas (Figure IV-22). This use is limited to trailing and possible overnight stops along the way. A summary of active use on the project area is as follows:

Livestock Utilization on Project Area

Type	Season	Number	AUM's	Area
Cattle	6/1-10/31	158	790	Hells Hole - Asphalt
Sheep	12/16-4/30	1800	943	Southam Canyon
Sheep	1/1-4/15	2650	1865	Hells Hole
Sheep	3/15-4/20	2500	585	Wagon Hound

In addition to these active permits on the project area, two additional permits are being held in non-use. These can be activated at some time in the future. Conditions of these permits are as follows:

Inactive Livestock Permits on Project Area

Type	Season	Number	AUM's	Area
Sheep	3/15-4/20	2500	585	Wagon Hound-Evac. S-4
Sheep	1/1-2/26	3000	1050	Wagon Hound-Evac. S-4

A total of approximately 4185 AUM's, therefore, are being permitted on the allotments in the project area. This is obtained by the grazing of 158 cattle and 6950 sheep at various seasons of the year. An additional 1635 AUM's (5500 sheep) are inactive at this time, but could be utilized in the future

3. NON-SCHEDULED SAMPLING

The non-scheduled sampling program included recording the identity, location, and activity of vertebrates whenever observed. These activities extended sampling in areas and at times of the day not covered by the scheduled sampling program or special studies.

During the year, no sightings were made of elk, wild horses or antelope on the project area. Two sightings of antelope were made relatively close to the project area. Sightings were as follows:

1) Twenty-one antelope observed on 11/4/75 1.8 km due north of F-5 (mouth of Asphalt Wash).

2) Forty-two antelope 1.6 km NE of A-3 (above White River and U-a) on 12/5/75.

Other opportunistic sightings such as the weasel seen in Southam Canyon (Figure IV-23) were reported in the previous sections as appropriate.

4. WORK SCHEDULED

The terrestrial vertebrate sampling program will be conducted in 1976 as in 1975. Another attempt to trap rodents in April will be made. In 1975 rodent trapping in April was suspended because freezing mortality was high.

The special vertebrate studies will be conducted in 1976 as in 1975 with the following exceptions:

(1) A browse study will occur in April after the sheep are moved off of the tracts to determine both sheep and deer browse utilization. Deer browse utilization will be measured in the fall and deer days' use will be determined by pellet group counts in the fall.

(2) A more extensive bat study will be conducted in May and August to develop a bat species list for the project area.

(3) The amphibian and reptile study will be modified to include a capture-removal method for lizards on one hectare plots in each vegetation type to obtain population estimates.

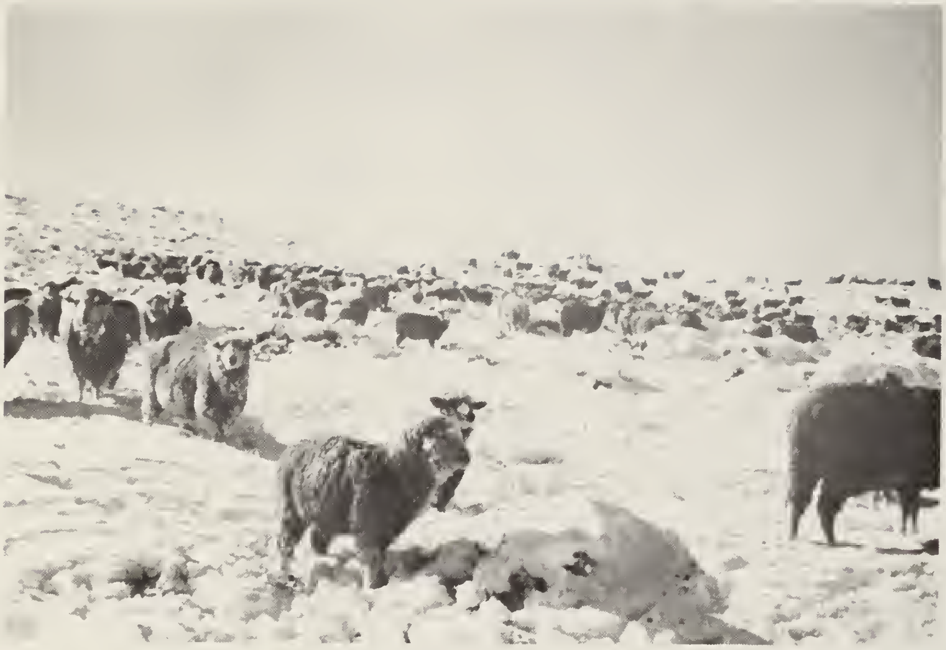


FIGURE IV-22 SHEEP ON THE TRACTS.

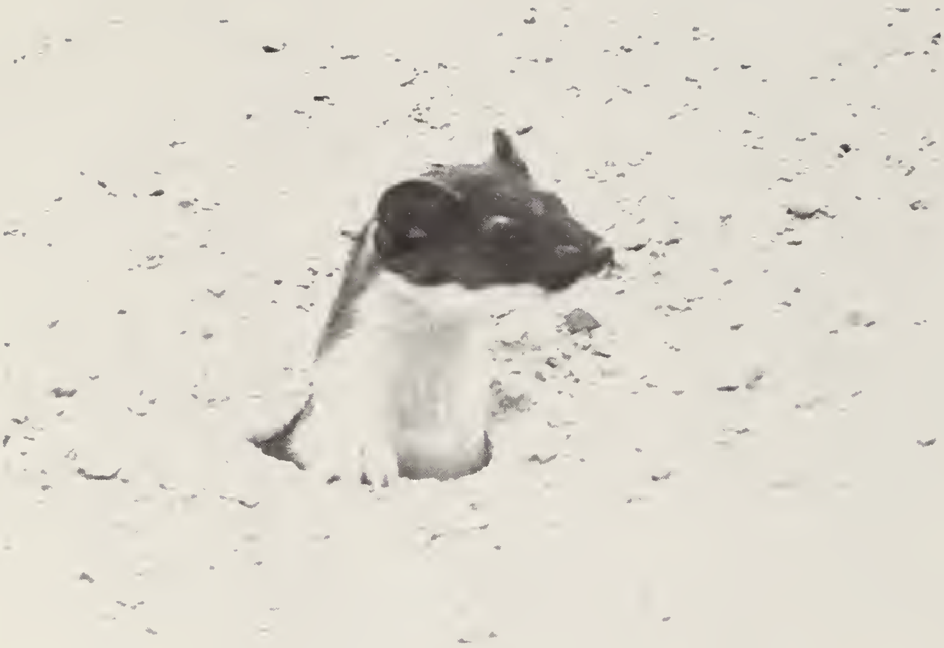


FIGURE IV-23 LONGTAIL WEASEL (MUSTELA FRENATA) NEAR AIR MONITORING STATION A-4.

C. TERRESTRIAL INVERTEBRATES

1. OBJECTIVES

The two primary objectives of the terrestrial invertebrate program were to compile a comprehensive species list and to provide information on season, habitat, host, and general abundance, at least for the dominant species.

2. METHODOLOGY

The methodology for the terrestrial vertebrate program is outlined in detail in the Partial Exploration Plan. Briefly, a species list is being compiled from arthropod specimens collected by--

(a) net collecting from flowers, leaves, soil surface, etc.

(b) routine net sweeping of vegetation

(c) malaise trapping

(d) searching in hiding or dwelling places under rocks, in logs, under bark, etc.

(e) using Berlese funnels to drive arthropods out of "duff" taken under trees and shrubs

(f) using a black-light trap and collecting from a sheet illuminated by a black light.

Once the specimens are collected, they are mounted, labelled, rough sorted and sent to Utah State University, Logan for determination; various other specimens are sent to specialists in the United States and Canada for additional determination. Arthropods used for quantitative studies are collected in monthly sweeps of each of 15 abundant plant species on the tracts (100 sweeps per plant species per month at three locations; White River Crossing, Evacuation Creek, and "ragged top" rock formation). (See Figure IV-6).

3. SUMMARY OF RESULTS

About 7,000 specimens were collected, mounted, labelled, and sorted by family. It is estimated that over 2,000 species of arthropods are included. Of these, about 500 have been determined to species or to genus (with species separated and designated 1, 2, 3, etc.).

The largest number of determinations (about 300) has been made in the insect order Diptera (true flies) (Table IV-41). The next largest number of determinations (about 150) has been made in the order Hymenoptera (bees, wasps, ants, etc.). About half of the species of Hymenoptera are still with specialists; other groups out for determination include noctuid and geometrid moths and all the various families of microlepidoptera (a group of super families of Suborder Frenatae of the Order Lepidoptera--Moths).

In September about 75 species of arthropods were photographed alive in their natural surroundings. Several of these photographs were included in the fifth quarterly report and four more are included here (Figures IV-24 to IV-27).

Insects collected in 1975 have not yet been sorted to species; however, based on approximately 1,000 species collected in 1974, it appears that the Order Hymenoptera (bees, wasps, and ants) accounts for at least one third of all the species. Diptera (flies, gnats, etc.) accounts for two sevenths of all species; Coleoptera (beetles), about one sixth; and Hemiptera (bugs, leafhoppers, etc.), one eighth. The rest constitute less than one twentieth of the total. These proportions are somewhat biased by the collecting methods used. More collecting and trapping at night would considerably increase the number of nocturnal Lepidoptera (moths) and would probably bring their diversity to near that of Hemiptera.

It is interesting that the degree of diversity in the different orders is very similar to that obtained in other intermountain desert areas such as Curlew Valley, Utah-Idaho. A survey made in Craters of the Moon, Idaho, yielded similar proportions, but more moths were counted because of more intensive night collecting. By contrast moist, temperate regions have a relatively greater diversity of Diptera, and tropical areas have a relatively greater diversity of Coleoptera and Lepidoptera.

Classification of the Habitats and Habits Represented

The terrestrial habitats in and around the project area can be classified variously with respect to the invertebrate communities, which were first grouped according to below-ground and above-ground habitats. Many forms, however,

TABLE IV-41

INSECTS OF OIL SHALE TRACTS, BONANZA, UTAH

Diptera

TEPHRITIDAE
Neaspilota sp #1
Tephritis avaneosa Coq.
Aciurina ferruginea Doane
Paraterellia sp #1
Euaresta aequalis Lw.
Euaresta tapetis Coq.
Paroxyna clathrata Lw.
Paroxyna sp. #1
Paroxyna sp. #2
Paracantha cultaris Coq.
Procecidochares minuta (Snow)
Procecidochares sp #1
Tripanea bisetosa Coq.
Trupanea wheeleri Curr.
Trupanea nigricoris Coq.
Trupamea sp #1
Oxyna utahensis Quisen
Oxyna aterimma Doane
Eutreta diana (O.S.)
Genus #1 sp #1
OTTI
OTTITIDAE
Melieria canus Loew.
Physiophora demandata (F.)
Ceroxys latiuscula (Loew)
Otites pyrrhocephala (Loew)
Otites sp #1
Oedopa capito Loew
Paroedopa punctigera Coq.?
Tritoxa pollinosa Cole
Tritoxa sp #1
Euxesta nitidiventris (Loew)
Euxesta sp. #1
Genus #1 sp #1
Genus #1 sp #2

SEPSIDAE
Sepsis neocynipsea M & S
Sepsis biflexuosa M & S

ANTHOMYZIDAE
Anthomyza sp #1

DROSOPHILIDAE
Scaptomuza sp #1
Scaptomyza sp #2
Drosophila sp #1

LONCHAEIDAE
Lonchaea sp #1
Dasiops sp #1
" sp #2
" sp #3

AGROMYZIDAE
Agromyza sp #1
" " sp #2
" " sp #3
Melanagromyza sp #1
Melanagromyza sp #2
Ophomyia sp #1
" " sp #2
" " sp #3
" " sp #4
Phytagromyza sp #1
" " sp #2
" " sp #3
" " sp #4
" " sp #5
" " sp #6
Ceradonta sp #1
Ceradonta sp #2
Haplomyza sp #1
Liriomyza sp #1
" " sp #2
" " sp #3
" " sp #4
" " sp #5
" " sp #6
" " sp #7
" " sp #8
Phytobia sp #1
" " sp #2
" " sp #3
" " sp #4
" " sp #5
Phytoliriomyza sp #1

MICROPEZIDAE
Micropeza sp #1

ASTEIDAE
Asteia multipunctata Sabr.

Chamaemyiidae
Chamaemyia sp #1
Leucopis sp #1
" " sp #2
" " sp #3

TABLE IV-41 (Cont.)

SCIOMYZIDAE
Pherbellia nana (Fall.)

TRIXOSCELIDAE
Trixoscela sp #1
"   "   sp #2
"   "   sp #3
"   "   sp #4
"   "   sp #5
"   "   sp #6
Spilochroa sp #1

TETHINIDAE
Pelomyia coronata Lw.
Tethina sp #1
Pelomyiella mallochi (Sturt.)
Pelomyiella melanderi (Sturt.)

LAUXANIIDAE
Camptoprosopella borealis Shew.
Minettia sp #1

HILARIMORPHIDAE
Hilarimorpha sp #1

SPHAEROCERIDAE
Leptocera sp #1
"   "   sp #2
"   "   sp #3

EPHYDRIDAE
Atissa sp #1
Allotrichoma sp #1
Allotrichoma sp #2
Ditrichophora sp #1
Discocerina sp #1
Discocerina sp #2
Ephydra nacellaria Egg.
"   sp #1
"   sp #2
Hydrellia sp #1
"   "   sp #2
"   "   sp #3
Mosillus tibialis Cress.
Ochthera mantis D.G.
Notiphilus sp #1
Pelina truncata Loew
Pelina sp #1
Illythea sp #1
Philygrid debilis Loew.
Paracoenia bisetosa Coq.

EPHYDRIDAE (continued)
Paracoenia twibida Curr.
Paracoenia sp #1
Parydra parasocia Claus.
Psilota compta (Meig)
Psilota olga Cress.
Lamproscatella sp #1
Scatella sp #1
Scatella sp #2
Genus #1 sp #1

CHLOROPIDAE
Chlorops lituratus Adams
Chlorops sp #1
Aphanotrigonum sp #1
Diplotoxa sp #1
"   "   sp #2
"   "   sp #3
"   "   sp #4
Diplotoxa recurra Adams
Lasiosina approximatonervis Loew
Lasiosina sp #1
Meromyza pratorum Meig
Thaumatomyia appropinqua Adams
Thaumatomyia sp #1
"   "   sp #2
"   "   sp #3
"   "   sp #4
"   "   sp #5
Cetema sp #1
Hapleginella conicola Greene
Gaurax sp #1
Elachiptera sp #1
Oscinella sp #1
"   "   sp #2
"   "   sp #3
"   "   sp #4
"   "   sp #5
"   "   sp #6 and sp #7
Olcella sp #1
"   "   sp #2
"   "   sp #3
"   "   sp #4
Hippelates pusio Loew
Hippelates sp #1
Siphonella neglecta Becker
"   "   sp #1
"   "   sp #2
"   "   sp #3
Eribolus nanus Becker
Lasiopleura sp #1
Genus #1 sp #1
Genus #2 sp #1
Genus #2 sp #2

TABLE IV-41 (Cont.)

MILICHIIDAE
Milichiella sp #1
Milichiella sp #2
Hemeromyia washingtona Meig.?
Hereromyia sp #1
Meoneura sp #1
Meoneura sp #2
Madiza glabra
Pholeomyia sp #1
Eusiphona sp #1
Leptometopa halteralis
Leptometopa latipes Meig.
Leptometopa sp #1
Desmometopa sp #1

SYRPHIDAE
Asemosyrphus polygrammus Lw.
Allograpta obliqua Say
Ceriana tridens Lw.
Baccha lemur O.S.
Eumerus strigatus Fall.
Eristalis tenax (L.)
Eristalis stipitator O.S.
Eupeodes volucris O.S.
Helophilus latifrons Lw.
Chrysotoxum integre Will.
Chrysotoxum ventricosum Lw.
Melanostoma sp #1
Melanostoma sp #2
Paragus bicolor F.
Paragus tibialis Fall.
Platycheirus sp. #1
Neocnemodon sp #1
Mesogramma marginata Say
Scaeva pyrastri L.
Syrphus sp #1
Metasyrphus sp #1
Tropidea quadrata Say
Sphaerophoria sp #1
Xylota flavitibia Bigot
Xylota sp #1
Volucella satura O.S.
Volucella candata Cum.
Syritta pipiens (L.)

CONOPIDAE
Physocephala texana Will.
Zodion fulbifrons Say
Zodion cinereiventre V.D.
Zodion americanum Weid.
Thecophora propinqua Adams
Thecophora nigripes Cam.
Robertsonmyia parva V.D.

STRATIOMYIDAE
Sargus cuprarius (L.)
Nemotelus canadensis Lw.
Nemotelus communus Hanson
Nemotelus sp #1

TABANIDAE
Silvius quadrivitattus Say
Tabanus punctifer L.

THEREVIDAE
Thereva johnsoni Coq.
Thereva fucata Loew.
Thereva sp #1

PHORIDAE
Megaselia sp #1
" " sp #2
" " sp #3
" " sp #4
" " sp #5
Phora velutina (Meig.)

EMPIDAE
Hemerodromia sp #1
Platypalpus sp #1
Platypalpus sp #2
Hilara sp #1
Neoplasta sp #1
Drapetis sp #1
Empis sp #1
" sp #2
" sp #3

BOMBYLIIDAE
Villa sp #1
" " sp #2
" " sp #3
" " sp #4
" " sp #5
" " sp #6
" " sp #7
Villa lepidota (O.S.)
Villa Syrtis Coq.
Villa lateralis Say
Villa capra Coq.
Villa morio (L.)
Villa sinuosa Weid.
Anthrax irroratus Say
Anthrax piesia Curran
Anthrax limatulus artemisia Marst.
Dipalta serpentina O.S.

TABLE IV-41 (Cont.)

Epacmus sp #1
Systoechus vulgaris Lw.
Toxophora virgata O.S.
Geron sp #1
" sp #2
" sp #3
" sp #4
" sp #5
Phthiria sulphurea Lw.
Phthiria sp #1
" " sp #2
" " sp #3
" " sp #4
" " sp #5
" " sp #6
" " sp #7
" " sp #8
Oligodranes sp #1
" " " sp #2
" " " sp #3
Peocilanthrax signatipennis (Cole)
Poecilanthrax willistoni (Coq.)
Exoprosopa caliptera Say
Neacreotrichus sp #1
Mythicomyia sp #1
" " sp #2
" " sp #3
" " sp #4
" " sp #5
" " sp #6
" " sp #7
" " sp #8
" " sp #9
" " sp #10
" " sp #11
" " sp #12
" " sp #13
" " sp #14
" " sp #15
" " sp #16
" " sp #17
Mythicomyia atra Cress.
Prorates sp #1

ASILIDAE
Proctocantha nearno Tns.
Efferia sp #1
" " sp #2
" " sp #3
Promachus aldrichii Hine

ASILIDAE (continued)
Philonicus sp #1
Mallophorina guildiana Will.
Stichopogon trifasciatus Say
Asilus cumbipilosa Addison
Asilus mesae Tucker
Asilus compositus Hine
Holopogon atrifrons Cole
Holopogon albipilosus Curran
Holopogon sp #1
Holopogon sp #2
Asilus tuxpanganus Ball
Asilus vescus Hine
Wilcoxia cineria James
Leptogaster sp #1
" " " sp #2
" " " sp #3
" " " sp #4

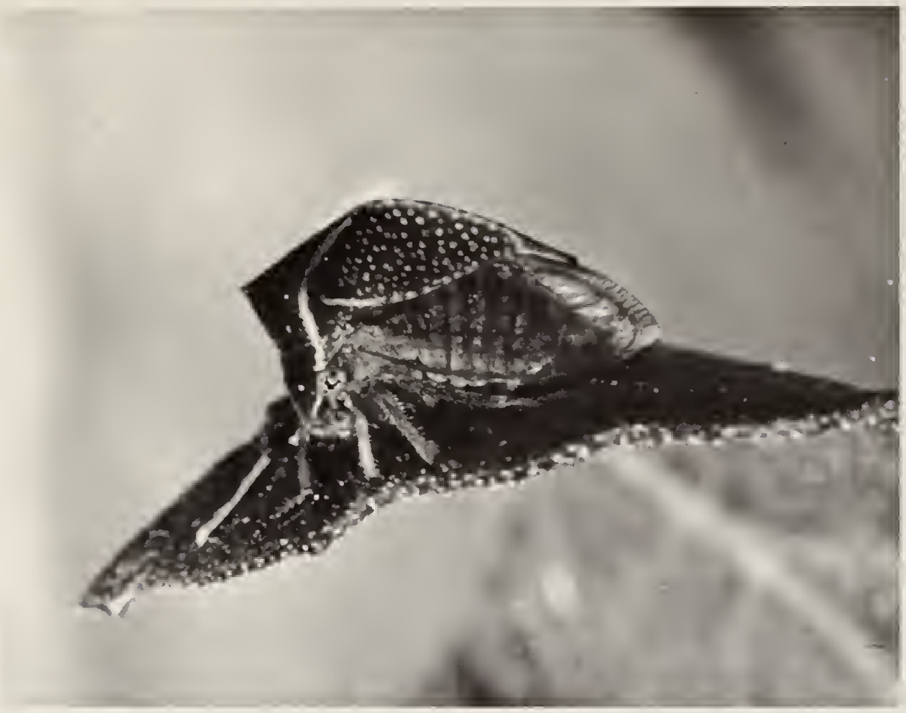


FIGURE IV-24 TREEHOPPER (*STICTOCEPHALA* SP.) ON A COTTONWOOD LEAF.

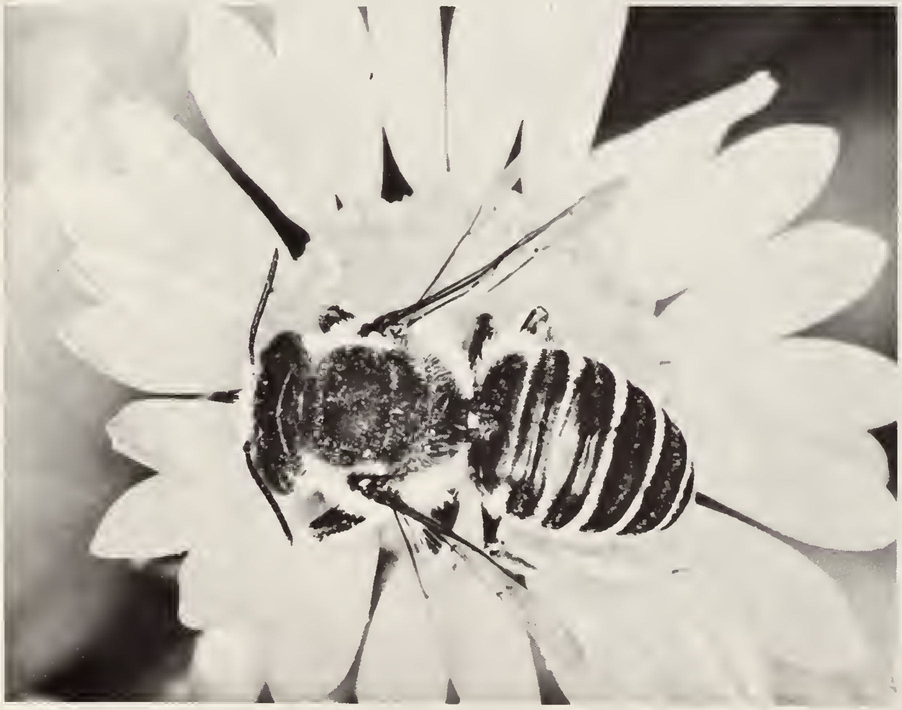


FIGURE IV-25 LEAF-CUTTING BEE (*MEYACHILE PARALLELA*) COLLECTING POLLEN AND NECTAR FROM GUM PLANT NEAR THE WHITE RIVER.

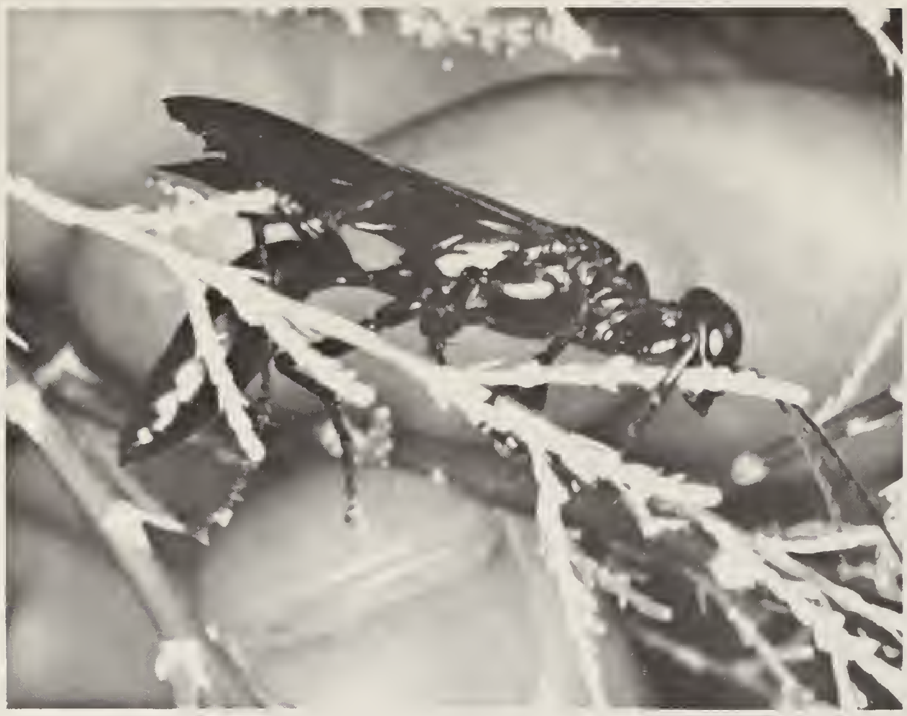


FIGURE IV-26 DEEP BLUE DIGGER WASP (CHLORIAN CYANEUM) ON SALT CEDAR.

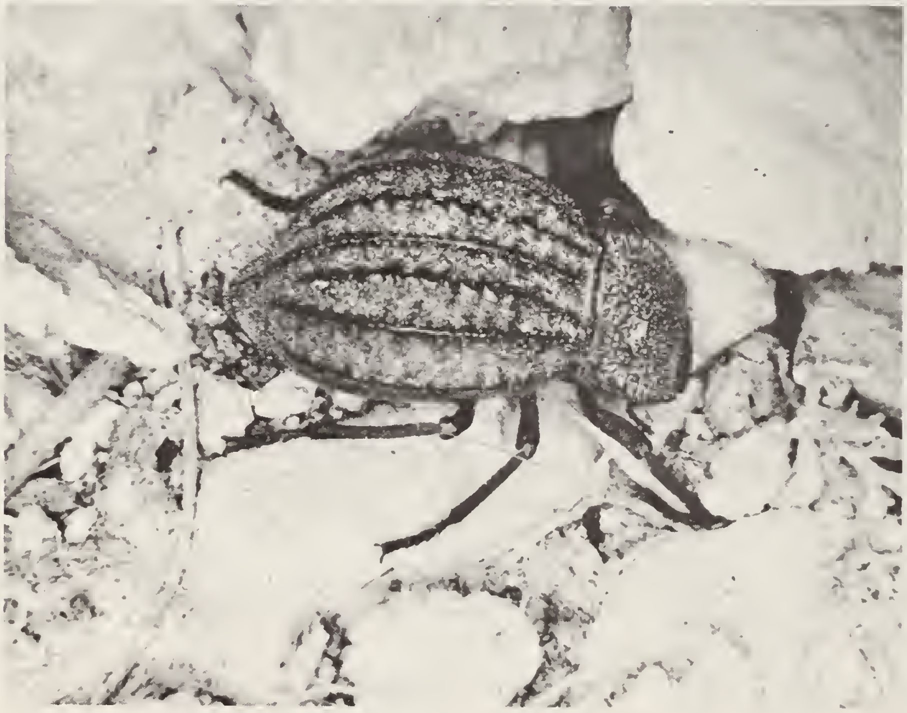


FIGURE IV-27 DARKLING GROUND BEETLE (GLYPTASIDA CRENNICOLLIS) UNDER A FLAT STONE NEAR STATE ROAD 45.

spend part of their life cycle in each of these habitats and others spend the night in the soil or plant crowns and the day above ground (or vice versa in the case of certain beetles, scorpions, etc.).

Below-ground forms: The below-ground forms include various coleopterans, such as ground beetles (Carabidae), rove beetles (Staphylinidae), larval forms of click beetles (Elateridae), darkling ground beetles (Tenebrionidae), and "June beetles" (Scarabaeidae). Many kinds of larval flies in the project area are also subterranean; the most prominent of these are robber flies (Asilidae); bee flies (Bombyliidae); stiletto flies (Therevidae); and many species of fruit flies (Chloropidae), root maggots (Anthomyidae and Muscidae), and otitids. Subterranean Lepidoptera are mainly in one family (Noctuidae) and are important herbivores, especially on seedlings and young shoots. Subterranean Hymenoptera include ants (most of which spend their foraging time above ground) and some bethylid wasps that prey on beetles they find in ground litter. There are also many species of nesting bees and wasps that place their brood cells below ground but forage above ground. Although termites are among the most important of subterranean insects, only one species (Reticulitermes sp.) is found on the tracts. This species feeds on, and lives in, dead or dying roots of desert shrubs. Collembolla (spring-tails) are abundant in the litter (and in the soil below), where they are especially important in the breakdown of such material. Various other arthropods, such as centipedes, millipeds, numerous mites, and some spiders, are also important in the underground habitat and under loose bark, logs, and stones.

The subterranean forms can be grouped into major and minor guilds, depending on how they use their resources. Many, such as larvae of click beetles and scarabs, feed on living or decaying roots. Others, such as darkling ground beetle larvae and termites, feed mainly on dead or decaying roots. Fly larvae in the families Anthomyidae and Muscidae tend to infest fleshy under-ground structures such as tubers and bulbs. Some, like fungus gnat larvae (Sciaridae and Mycetophilidae), feed primarily on fungus hyphae. Many under-ground insects are predaceous (carabid beetles, rove beetles, larval robber flies, and larval empid flies (Empidae); and some are external parasites (tiphiid and scoliid wasps) or internal parasitoids (bethylid wasps).

The non-insect soil arthropods are mainly predaceous (centipedes, spiders, sun spiders, numerous mites); others are herbivorous, and feed on roots or root hairs (millipeds, mites, and sow bugs) or on decaying root material and fungi (the same as other members of the last three groups). Minor guilds include such forms as subterranean ant guests and scatophags in rodent burrows.

Above-ground forms: Above-ground habitats in the Bonanza area can be divided into two categories--riparian and upland--and can be considered in relation to the plant community involved. The riparian can be subdivided into the cottonwood-willow-tamarisk type (White River) and the tamarisk-greasewood type (Evacuation Creek). The upland plant-community habitats can be divided into numerous narrowly defined plant communities or into a few broadly defined ones such as juniper-sage versus shadscale-sage versus greasewood sage, etc. Since the plant communities in the project area have overlapping interzones that often seem to exceed the definable zones, many of the insects will overlap in definable plant communities, which makes it even harder to characterize the faunas throughout the area according to plant communities. A simple solution is to characterize the insects associated with each plant species or higher taxon; for example, grass insects, sagebrush insects, or willow insects.

Several species of jumping plant lice are restricted to Artemisia spp., and several kinds of bees in the project area (Perdita, Colletes, etc.) are so specialized that they collect pollen only from a single plant genus. Insects so specialized may be as much the exception as the rule, since there is a complete intergrading series from the extreme specialist to the almost complete generalists. Other features in the habitat can be as important as the food resource. For example, one large bee (Anthophora occidentalis) nests only in a few vertical south-facing or west-facing clay banks by permanent streams and collects pollen almost exclusively from thistles. Although there is a large colony near the Evacuation Creek Bridge, the bees have never been seen on thistle plants growing only 0.8 km (0.5 mi) away. Proper nesting conditions here apparently dictate the site and force the bees to use a host plant other than the normal one. Similarly, many kinds of bees and wasps nest along the sandy banks of Evacuation Creek. They may collect pollen from certain plants or store only certain insect groups associated with particular plant species. Even though these plants occur widely, the insects are found only where the proper nesting conditions are available.

Above-ground arthropods are much more easily subdivided to their guild rather than to community relationships; however, even the guild classification breaks down in many respects. Many Hemiptera (like the boxelder bug) that ordinarily suck sap will opportunistically suck insect blood, and others (like the pirate bugs) that ordinarily suck insect blood will occasionally imbibe plant juices. Obviously, these two habits are morphologically somewhat compatible.

Many species of insects belong to one guild as larvae and another as adults (this is normal for holometabolous forms like beetles, wasps, flies, and moths). For example, most moths devour vegetation (in many cases from a narrow plant spectrum) as larvae, but feed only on nectar (wherever found) as adults. If nectar-producing plants were completely suppressed (or not allowed to bloom) numerous elements of insect fauna would disappear even if the larvae food sources remained intact.

Some prominent arthropod guilds of the Bonanza area are as follows: sapsuckers on leaves (leafhoppers, jumping plant lice, many aphids, many mirid bugs); leaf perforators (adult chrysomelid beetles and some adult weevils); sapsuckers on roots (cicada nymphs, mealy bugs, and many aphids); feeders on fungi by extra-corporeal digestion (fungus gnats), or by direct chewing (various families of fungus beetles); suckers of vertebrate blood (mosquitoes, horseflies, etc.); devourers of xylem and phloem in wood (larvae of long-horned and buprested beetles); nectar imbibers (most adult Lepidoptera and Hymenoptera and many adult beetles and flies); Ambushers/bloodsuckers of insects (ambush bugs and crab spiders); and trappers/ bloodsuckers of insects (many spiders). The guild breakdown and the list of members could be expanded almost indefinitely, but this would be beyond the scope of this report.

Arthropods of Nuisance or Public-Health Significance

Some insects in the area are significant pests to man and domestic animals or are potential public-health hazards. Among the Diptera, a mosquito (Aedes nigromaculis), a biting midge (Leptoconops furens), and a deer fly (Sylvius quadrivittatus) are the principal biting species. All are extremely annoying when present in large numbers in the riparian areas, and L. furens is also troublesome in the more upland areas. Several other biting Diptera, such as the biting midges (Culicoides), other mosquitos, other horseflies or deerflies (Tabanidae), and the stable fly (Stomoxys calcitrans), probably exist in the area and may become pests.

Ticks have not been collected, although they undoubtedly are found on the resident deer. The black widow spider and a species of scorpion are also present. The scorpion is harmless, and the black widow's bite is painful and can cause cramps but is usually not dangerous. Filth-carrying flies, such as houseflies and blow flies, are present but not abundant. The most common is Phormna regina, a blow fly that commonly breeds in carcasses of deer and large livestock.

4. CONCLUSIONS

The objectives for the program are being attained, but conclusions have not yet been made because the species identifications are not in final form.

5. WORK SCHEDULED

Field collecting during 1976 will be confined mostly to a few methods, such as light trapping, bait trapping, etc., that were not extensively used in 1975. Emphasis will be on obtaining determinations for the many species already collected.

Taxonomic classification of invertebrate species will continue. During the sixth and seventh quarters, the quantitative samples now in storage will be examined, and the numbers of the various species will be counted as much as possible. With each sweep roughly estimated to sample 0.14 cu m (1/2 cu ft) of vegetation, it should be possible to make crude population assessments by correlating the counts with the known densities and sizes of the plants involved.

D. AQUATIC BIOLOGY

1. OBJECTIVES

Aquatic systems are being studied on the tracts to document conditions in the White River and Evacuation Creek. The study was designed to determine the composition, abundance, and temporal and spatial distribution of aquatic macrophytes (vascular plants), periphyton, plankton, macroinvertebrates, and fish. A secondary objective is data collection by standard methods that can be repeated; this is necessary because of the large number of samples necessary to produce statistically reliable data (Needham and Usinger 1956).

2. METHODOLOGY

The methods of sampling and analyses are those of the EPA, USGS, public health agencies, and other groups involved in applied aquatic biology. The methods are discussed by APHA (1971), Usinger (1971), Slack et al. (1973), Weber (1973), and Welch (1948).

The methods used in this study are described in the Partial Exploration Plan. The original scope of work has been modified as follows:

(a) Aquatic macrophytes are virtually absent from the study area and are therefore not being sampled.

(b) Floating artificial substrates will be used for collecting periphyton. One sample strip from each periphyton collection is preserved in formalin. The accumulated growth is scraped into the preservative from the sample strip with a "rubber policeman." The sample jar is closed and agitated violently to disperse algal cells into the preservative. Aliquots are placed in a Sedgwick Rafter cell, and algal cells are counted in accordance with Standard Methods, SEC. 601 D (APHA 1971).

(c) Plankton will not be sampled for chlorophyll. Chlorophyll determinations are conducted in the surface water study.

(d) Captured fish will be identified, fin clipped, and released in 1976, as permitted by the Utah Division of Wildlife Resources.

Because natural aquatic populations tend to clump, or occur in patchy distribution, there is often a considerable difference between samples taken from apparently similar stream sections or from different sections of a riffle; therefore, samples are taken from the same location as much as possible. The sampling stations and the points at which various samples are collected are shown in the fourth quarterly report (also see Figure IV-6).

3. SUMMARY OF RESULTS

a. Habitat

The White River and Evacuation Creek are the major aquatic ecosystems in the study area. The intermittent streams in many of the canyons that dissect the site run only briefly during snowmelt or after thunderstorms, and therefore their biological importance is limited. There are no natural lakes in the study area, although a small sump near the White River bridge occasionally contains water, making it an important breeding place for mosquitos and amphibians.

The White River headwaters are in western Colorado and the river discharges into the Green River near Ouray, Utah. Its total length is approximately 400 km (240 mi), approximately 28 km (17.5 mi) of which flows through the project area. Evacuation Creek rises near the Utah-Colorado border and flows for 7 km (4.3 mi) through the study area. The stream section below Utah State Road 45 usually maintains some flow throughout the year, but the portion above State Road 45 is often dry on the surface.

Conditions in the White River vary considerably throughout the year. From August through April, discharge averages about 10.6 m^3 per sec (375 cfs). Spring runoff from melting snowpack in the upper watershed begins in May, and the discharge increases to a peak of over 99 m^3/sec (3,500 cfs) in late June and early July. Ice forms on the river in December and lasts until March. During the winter of 1974-75 ice covered most of the section downstream of the Bonanza bridge, but a channel in the middle of the river remained open in the section upstream from the bridge.

Abiotic physical and chemical parameters of the aquatic environment regulate the composition of the biological community in the river and the survival and reproduction of each organism in the community. These parameters include flow velocity, temperature, dissolved oxygen concentration, pH, dissolved solids concentration, turbidity, and the nature of the bottom materials (Hynes 1960, 1970). Biological conditions of the White River are primarily regulated by turbidity and bottom structure; seasonal discharge and alkalinity are the most important influencing factors in Evacuation Creek.

Turbidity affects aquatic biota by limiting light penetration. The rate of photosynthesis is dependent on the amount of light available to plants (algae) in the water, and all animals are eventually dependent on the food produced by photosynthesis. Photosynthesis is also an important contributor of dissolved oxygen.

During the normal (low flow) period of the White River, the turbidity averages about 75 JTU (Jackson turbidity units), and the stream averages approximately 30 m (100 ft) wide. Pools are 1.2 m to 1.5 m (4 ft to 5 ft) deep, and the channel averages about 0.6 m (2 ft) deep. The channel meanders across a narrow floodplain, often splitting and merging to form small islands. During low flow conditions, transparency averages about 15 cm (6 in.), allowing adequate light to reach the substrate to produce moderate algae growth.

From May through August the river runs high. Turbidity averages close to 400 JTU, and most of the time it is over 500 JTU. Following snowmelt or thunderstorms, runoff occurs rapidly; and because most of the watershed is sparsely vegetated and has easily erodible soils, runoff contributes a large volume of materials to the water. During this period transparency is less than 2.5 cm (1 in.). The stream is loaded with suspended materials that range from silt particles to tree trunks. These materials strongly influence conditions in the river: turbidity and dissolved solids increase, suspended solids settle on the substrate, and riffles and islands are submerged so that the river becomes a homogeneous, turbid channel. Productivity is halted by the absence of light, and scouring action removes much of the existing algal flora. High flows may also cause minor channel changes that redistribute fish and insect populations (Hynes 1970).

The bottom structure of a river determines the kinds of microhabitats available to organisms. These habitats are extremely important in lotic (flowing water) ecosystems like the White River. The general chemical and physical conditions of riverine systems usually represent conditions that occur within the major volume of water but do not accurately reflect the microenvironmental conditions that exist within millimeters of the substrate or immediately downstream of, and beneath, stones. Bottom materials provide hydraulic resistance to flow and form a thin boundary layer where current velocity is relatively low. Invertebrate and algal populations that could not survive in open water often flourish in these smaller, protected microenvironments. Since irregular bottoms provide more habitat, population numbers and species diversity are usually greater in rocky areas than in sand or silt.

The nature of the river bed is a major controlling factor in the distribution of invertebrates (Hynes 1960). Two general substrate types are usually recognized, both of which occur in the White River: "eroding," composed of stones or gravel; and "depositing," composed of mud or silt. Eroding areas are more common in upstream river sections, and depositing areas are more common in downstream river sections. Eroding areas support a rich assortment of algae, herbivores, and predators. The inhabitants of the depositing, or silty, areas consist mostly of scavenging worms and insects that feed on detritus. The sandy bottoms are an intergrade in particle size, but are relatively free of organisms. The distribution of these different areas within a stream section is important in determining its floral and faunal characteristics. The suspended materials, which cause turbidity, settle onto the river bottom, covering the stones and rubble and increasing the silted area. The overall effect is greatly reduced productivity.

The other chemical and physical parameters--temperature, dissolved oxygen, pH, and dissolved solids--are also of biological importance in the White River and Evacuation Creek. In the White River maximum water temperatures above 24° C (75° F) occur in August. This temperature precludes trout populations but has little effect on most other animals. Dissolved oxygen concentrations average 91 percent of saturation. These concentrations are adequate to support aquatic biota. The pH level is usually above 8.0 and averages about 8.4. The maximum pH is reported in excess of 10, a level harmful to many organisms.

b. Aquatic Macrophytes

True aquatic macrophytes do not occur in Evacuation Creek or the White River, probably because of adverse chemical characteristics, fluctuating water levels, turbidity, and unstable stream beds. Stream water in the area ranges from hard to very hard, and alkalinity is high. Hardness (mg/l Ca and Mg) averages nearly 300 in the White River and over 1,100 in Evacuation Creek; alkalinity (mg/l $CaCO_3$) averages 200 in the White River and over 400 in Evacuation

Creek. The many plants that require soft water and dissolved CO_2 cannot survive. Mosses and liverworts in particular are usually found in soft or acid water (Hynes 1970). Some mosses are able to survive in the vicinity of aquifer seeps along Evacuation Creek near Station F-6. Mosses are restricted to areas of permanent water, because they do not possess an internal water transport system.

The water levels of Evacuation Creek and the White River fluctuate in a fairly predictable manner, as shown in streamflow records (USGS 1973), and are probably important in limiting aquatic macrophytes. The pattern of spring flooding creates conditions similar to those of the barren "drawdown zone" that borders many artificial lakes, where littoral areas are alternately dried and submerged. When areas along the river bank are submerged, the turbid water restricts the penetration of light for plant establishment and survival; any that do become established are eliminated when flow recedes and the soil becomes dry (Warner et al. 1974).

c. Periphyton

Periphyton is defined as a group of microorganisms (community) associated with the surface of submerged objects (APHA 1971). Periphyton usually consists of diatoms, minute filamentous algae, rotifers, protozoans, etc. The term is used in this section to include all attached filamentous algae. Under this definition, periphyton in the area is composed almost exclusively of diatoms and the green algae Cladophora glomerata, and several blue-green algae.

Periphyton is important because of its position at the base of the food chain: in the absence of aquatic vascular plants and planktonic algae, it is the primary producer supporting the aquatic fauna. Because many aquatic animals feed on terrestrially derived detritus, periphyton is not the sole food source, but it is nevertheless very important for aquatic insects and many fishes.

Several methods have been used to collect quantitative periphyton data, but to date they have produced little useful information. Most multiplate samplers first deployed in October 1974 were carried away by flood debris, buried in silt, or left stranded by receding floodwaters. In spring 1975, the multiplate samplers were replaced with floating samplers similar to those used by the USGS. With the exception of those at Stations F-3 and F-6, all were carried away by flood water and debris (see Quarterly Report No. 4). The samplers were replaced, but the new samplers became waterlogged and sank so low in the water that the collecting strips were either obscured by turbid water or covered with silt.

The samplers were modified, waterproofed, and placed back in service during November 1975. These models performed satisfactorily and yielded samples for analysis by the USGS laboratory. These samplers must remain in the water for approximately four weeks to produce satisfactory results. They cannot be used if the water freezes. During flood stage and high turbidity, the abrasive action of suspended materials apparently reduces the effectiveness of any sampling method. The shifting bottom quickly obscures artificial substrates sometimes used (bricks, anchored styrofoam, etc).

The growth rate of algal periphyton is controlled by the length of photoperiod, nutrient content of the water, temperature, turbidity, and many other factors. Population abundance is usually cyclic. In most waters, standing crops peak in spring, decline through summer, and reach another, usually lesser peak in autumn (Hutchinson 1967; Hynes 1970).

In the White River, algal abundance is controlled by snowmelt runoff: during spring, when the river is high and turbid, algal growth is slow and part of the standing crop is removed by high current velocity and scouring. As a result, the algal standing crop is low in the White River at a time when it is near maximum in other waters. This condition persists until late July or early August. As the water level recedes, transparency improves and the algae begin a period of rapid growth. In most years, the standing crop is probably at its highest in late August.

The growth cycle is further influenced by thunderstorm activity or seasonal variation. The effect of thunderstorms is the most obvious in Evacuation Creek. Summer thunderstorm runoff almost completely strips the streambed of attached algae, and the water level recedes rapidly. Within a few days a thick crop of diatoms is apparent on stones on the bottom (see _Quarterly Report No. 4_).

The periphyton community in the White River is composed mostly of the green alga _Cladophora_--the dominant alga in the River--and several genera of diatoms. The alga occurs on shallow submerged stones throughout the study area; and during summer and autumn, when the water is low and relatively clear, the alga forms green mats in shallow riffle areas. Other filamentous green algae are comparatively rare. _Spirogyra_, _Ulothrix_, and _Mosigeotia_ spp. appear irregularly in samples. _Vaucheria_ sp., a yellow-green alga, is locally abundant at Station F-1. Unicellular green algae are usually an important component of the periphyton community, but they are not common in the White River. *Euglena* sp. appear irregularly, and *Chlorella* sp., which is generally rare, was abundant in two samples.

Cocconeis placentula is the dominant diatom through most of the year. It occurs principally as an epiphyte on *Cladophora glomerata*, and hence its abundance is related to that of *Cladophora*: When the *Cladophora* population is reduced, *Cocconeis* becomes infrequent. *Gomphonenia olivaceum* is an important diatom that usually occurs as short brown filaments on the downstream face of stones.

The most important of the blue-green algae occur as a crust on the more deeply submerged stones. These algae apparently require less light than *Cladophora*, since they appear to be more abundant at greater depths. *Phormidium* sp. and *Oscillatoria* sp. are the most commonly collected. *Spirulina subsalsa* was abundant in February, 1975.

The genera of algae in the White River do not appear to have particular significance as indicators of environmental conditions. *Cladophora glomerata* and *Cocconeis placentula* are usually the most abundant species. APHA (1971) considers both of these to be "clean water algae."

By August 1, 1974, spring runoff in the White River had ended and discharge was down to 9.2 m^3/s (325 cfs); transparency was 20 cm (8 in.) and shallow riffles were densely colonized by *Cladophora glomerata*. On August 1, 1975, discharge was still over 28.3 m^3/sec (1,000 cfs). The riffles were obscured by the high water level, and little algae occurred on the submerged stones. Algal colonies similar to those of 1974 did materialize later in 1975.

Although the samples collected in June and November 1975 were inadequate as a basis for conclusions, they did provide some insight into growth-regulating factors. Evacuation Creek was low and clear during both sampling periods, and the sample strips accumulated abundant algal growth. During June the White River was in a flood stage with very high turbidity (800+JTU). The strips removed from Station F-3 (near the White River bridge) showed no color on the sample strips, which were always submerged; and yet the top side of the float, which was never submerged but always wet, was thickly colonized by *Gomphonema olivaceum* and *Navicula* sp. The scouring action of silt-laden current apparently prevented the accumulation of algal growth. June sample strips from Station F-6 (Evacuation Creek) were well colonized and yellow-green in color. The community proved to be composed almost exclusively of six diatom species, predominantly *Navicula cryptocephala* (species not confirmed) and *Fragil~~l~~aria* sp.

According to laboratory results, the November sample strips contained considerably less growth than those of June. This could be due to lower temperatures and reduced photoperiod or to errors in the analysis of June samples. The June samples from Evacuation Creek were reported to contain average chlorophyll b concentrations of 12.9 mg/m^2. Chlorophyll b is produced only by green algae and euglenids (Scagel et al. 1967). Microscopic examination of these sample strips showed that the accumulated algae was composed almost exclusively of diatoms (Figure IV-28).

Average chlorophyll concentrations in milligrams per square meter are shown in Table IV-42. The June samples were analyzed by TayCon Laboratories, Salt Lake City. November determinations were made by the USGS.

Although quantitative data are not available, it is safe to assume that the abundance of the periphyton community is regulated by physical conditions in the river. The variations in flow, turbidity, and suspended materials that impair the effectiveness of samplers also operate against the natural periphyton communities. The concentration of nutrients and other chemical conditions are adequate for algal production (Provasoli 1969), as indicated by the rapid appearance in the riffles of dense algal communities when discharge recedes and transparency improves.

d. Plankton

Plankton are organisms that are free floating in the water. They are immobile at least to the extent that their movements are ineffective in counteracting motion imparted by current. Hynes (1970) reviewed literature pertaining to plankton and concluded that only very large river systems support a community of truly planktonic organisms. This is true for the White River and Evacuation Creek: only rarely are truly planktonic organisms such as *Cosmarium* sp. or *Asterionella* sp. encountered. The organisms taken in plankton samples are almost exclusively sessile diatoms or other algae that have washed free of their substrate.

Because nearly all phytoplankton in the area are derived from periphyton, the species composition and relative abundance of the two communities are similar. Because most diatoms are less firmly attached to substrates than the filamentous algae, they constitute a major portion of the planktonic samples. Zooplankton is almost non-existent in the streams. Copepods were collected on one occasion and ciliated protozoans appear infrequently.

FIGURE IV-28 VTN PERSONNEL STUDYING COLLECTED ORGANISMS AT THE FIELD LABORATORY.

FIGURE IV-29 VTN AQUATIC BIOLOGIST COLLECTING AQUATIC INVERTEBRATES IN THE WHITE RIVER.

FIGURE IV-30 UTAH DIVISION OF WILDLIFE RESOURCES PERSONNEL ELECTRO-SHOCKING FISH IN THE WHITE RIVER.

TABLE IV-42

CHLOROPHYLL CONCENTRATIONS (mg/m^2)

Date	Station	Chlorophyll a	Chlorophyll b	Biomass - Pigment Ratio
June	F-3	2.45	2.9	-*
	F-6 (5-2)	11.3	12.9	-
November	F-3	0.2	0.0	1,400
	F-4	0.0	0.0	-
	F-6	1.7	0.1	93
	S-11 (Near F-5)	0.7	0.0	680

*No data

Plankton is collected with a water sampling bottle, strained through a plankton net, and counted with a Segwick-Rafter Counting Cell. The concentration of phytoplankton has ranged from 7,400 cells to 78,500 cells per liter. Plankton data from major samplings are shown in Table IV-43 with the autumn peak appearing to be much higher than that of spring.

In most systems, plankton has cycles of abundance. Population levels usually peak in the spring and to a lesser extent, in the autumn (Hutchinson 1967). In the White River, this pattern is probably altered by fluctuating river stages. Butcher et al. (1937) found that river plankton counts are much higher during periods when the water level is rising because rising waters tear away much of the periphyton community, and the organisms appear in plankton samples.

Samples from April 1975 were taken at a time when the river stage was descending. At that time the samples averaged 11,700 cells per liter. In September 1975 the river had been at a relatively low and constant stage for several months, and the standing crop of periphyton was contributing great numbers of diatoms to the plankton. September samples averaged nearly 78,500 cells per liter.

e. Macroinvertebrates

Aquatic insects are one of the most ecologically important groups in streams because they are near the base of the food chain. In fact, Day (1971) refers to the mayfly nymph as the "cattle or rabbits of the aquatic environment," because they are so important in transforming plant tissue into animal matter. The same statement could be applied to many of the stonefly nymphs, caddis larvae, and other species with similar habits. Carnivorous insects prey on those species that feed on algae and detritus, and serve in turn as prey for other invertebrates and fish. Because of their function, all are very important links in the food web (Odum 1971). Immature insects are by far the most significant group of aquatic invertebrates in the oil shale area (Table IV-44).

Evacuation Creek and the White River contain very different habitats for macroinvertebrates. Evacuation Creek is a smaller stream system that exhibits greater fluctuation in flow characteristics than the White River. Thunderstorms may increase flow by a factor of 10 within hours. Within two or three days after the storm, discharge recedes to the "normal" 0.028 m^3/sec (1 cfs) or less. The streambed

TABLE IV-43

QUANTITATIVE PLANKTON DATA

Sample Date	Average No. Cells/ml.	S^2 (1)	$S^{(2)}$	No. of Samples Analyzed	No. Required(3)	CL(4)
October, 1974	13.4	92.5	9.6	5	120.7	62%
April, 1975	11.7	41.9	6.5	5	71.9	66%
July, 1975	7.4	1.3	1.1	5	5.6	92%
September, 1975	78.5	524	23	5	20	79%

---

(1) Sample Variance

(2) Standard Deviation.

(3) Number of samples required to estimate true mean within 25% at a 90% level of statistical confidence.

(4) Confidence level for 5 sample analysis. Rounding may cause slight disagreement between (3) and (4).

TABLE IV-44

SYSTEMATIC LIST OF AQUATIC INVERTEBRATES COLLECTED FROM THE WHITE RIVER (1974-75) WITH REFERENCE TO FOOD HABITS OF EACH TAXON[a]

Taxa	Detritivore	Herbivore (Algae)	Predator	Variable
Phylum Annelida				
Class Oligochaeta				
Order Plesiopora				
Family Tubificidae				
Tubifex sp.[b]	X	X		
Limnodrilus claparedianus	X			
Family Naididae				
Naidium osborni	X			
Naidium sp.	X			
Family Aelosomatidae				
Aelosoma sp.	X			
Phylum Arthropoda				
Class Crustacea				
Order Copepoda		X		
Order Isopoda	X	X		
Class Arachnida				
Order Hydracarina				X
Class Insecta				
Order Collembola				
Family Poduridae	X			
Order Plecoptera				
Family Taeniopterygidae				
Oemopteryx fosketti	X			
Family Capniidae				
Capnia sp.	X			
Family Perlidae				
Acroneuria abnormis			X	X
Family Perlodidae				
Isogenoides colubrinus			X	X
Isoperla longiseta			X	X
Order Ephemeroptera				
Family Siphlonuridae				
Isonychia sicca[b]	X	X		

---

[a] Modified from Baumann et al. (1975)

[b] Reported by Baumann; not collected in this study

TABLE IV-44 (Continued)

Taxa	Detritivore	Herbivore (Algae)	Predator	Variable
Family Baetidae				
Baetis spp.	X	X		
Callibaetis sp.	X	X		
Dactylobaetis cepheus	X	X		
Paracloedes sp.[b]	X	X		
Pseudocloeon sp.	X	X		
Family Oligoneuridae				
Lachlania saskatchewanensis	X	X		
Family Ametropodidae				
Ametropus albrighti[b]	X	X		
Family Ephemerellidae				
Ephemerella inermis	X	X		
Family Heptageniidae				
Heptagenia elegantula	X	X		
Rithrogena undulata	X	X		
Family Leptophlebiidae				
Choroterpes albiannulata	X	X		
Paraleptophlebia sp.[b]	X	X		
Traverella albertana	X	X		
Family Tricorythidae				
Tricorythodes edmundsi	X	X		
Tricorythodes minutus				
Family Polymitarcidae				
Ephoron album	X		X	
Order Odonata				
Family Gomphidae				
Gomphus intricatus			X	
Ophiogomphus severus			X	
Family Agrionidae (= Calopterygidae)				
Hetaerina americana			X	
Family Coenagrionidae (= Agrionidae)				
Argia sp.			X	
Order Hemiptera				
Family Corixidae				
Corisella sp.		X		
Hesperocorixa sp.	X	X		
Ramphocorixa sp.	X	X		
Sigara sp.	X	X		

TABLE IV-44 (Continued)

Taxa	Detritivore	Herbivore (Algae)	Predator	Variable
Family Notonectidae			X	
Notonecta sp.			X	
Family Gerridae				
Gerris (remigis?)			X	
Metrobates sp.[b]	X		X	
Family Veliidae				
Rhagovelia distincta	X		X	
Family Mesoveliidae				
Mesovelia mulsanti	X		X	
Family Saldidae				
Saldula sp.	X			
Order Megaloptera				
Family Corydalidae				
Corydalus sp.[b]			X	
Order Trichoptera				
Family Rhyacophilidae				
Subfamily Glossosomatinae		X		
Family Hydropsychidae				
Hydropsyche sp.	X	X		
Family Hydroptilidae	X	X		
Family Limnephilidae				
Limnephilus sp.	X	X		
Family Leptoceridae				
Leptocella alba	X	X		
Family Brachycentridae				
Brachycentrus sp.	X	X	X	
Order Lepidoptera				
Family Pyralidae[b]	X	X		
Order Coleoptera				
Family Elmidae				
Microcylloepus sp.[b]		X		
Optioservus sp.[b]		X		
Stenelmis sp.		X		
Zaitzenia sp.		X		
Family Dytiscidae				
Dytiscus ooligbukii			X	
Hydroporus sp.			X	
Agabus sp.			X	

TABLE IV-44 (Continued)

Taxa	Detritivore	Herbivore (Algae)	Predator	Variable
Order Diptera				
Family Blepharoceridae				
Blepharicera sp.		X		
Family Tipulidae				
Hexatoma sp.	X			
Family Dixidae		X		
Family Culicidae				
Culex tarsalis	X	X		
Family Simuliidae		X		
Simulium sp.		X		
Cnephia sp.		X		
Family Chironomidae				
Chironomus riparius[b]	X	X		
Chironomus sp.	X	X		
Endochironomus sp.[b]	X	X		
Microtendipes sp.	X	X		
Palpomyia sp.	X	X		
Psectrocladius sp.[b]	X	X		
Stictochironomus sp.	X	X		
Cryptochironomus sp.	X	X		
Cardiocladius sp.	X	X		
Orthocladius sp.	X	X		
Metriocnemius sp.	X	X		
Symoyocladius sp.*			X	
Family Ceratopogonidae	X	X	X	
Family Stratiomyidae	X			
Family Tabanidae				
Silvius notatus		X		
Family Rhagionidae				
*Atherix variegata**				X
Family Empididae	X			

*Parasitic

provides little refuge for resident invertebrates, and spates scour the streambed clear of all organisms (see Quarterly Report No. 4). During late summer, portions of the stream above Station F-6 go dry, which has resulted in establishment of organisms that are either quite mobile or have short life cycles.

Aquatic invertebrates in the lease areas are well suited for the environments of the White River and Evacuation Creek, because their food habits and life histories are adapted to the constantly changing conditions.

Most of the common species are detritivores or herbivores. Detritivores feed on bits of organic material, and herbivores feed on algae. The only important predator is the nymph of the dragonfly, Ophiogomphus severus. The high percentage of detritivores in the fauna indicates that the aquatic systems derive much of their energy from terrestrial sources, as noted by Baumann (1975). A detritus base tends to buffer aquatic systems against disturbances such as current (Odum 1963 1969). The organic detritus provides food and habitat to consumer organisms and reduces erodability (Bormann et al. 1969). In autotrophic systems, living biomass serves the same function, but the living material requires a constant influx of energy. Since detritus requires no intrasystem energy, it lends stability and provides food to consumers without imposing an energy drain on the system (Fisher and Likens 1973).

Many of the herbivores of the project area are facultative detritivores, i.e., they feed on algae if it is available. When not available, they can subsist on a detritus diet.

The density and diversity of invertebrate populations vary according to the time of year they are sampled, the kind of substrate, and the water quality conditions (see Figure IV-29).

Time of Year

Seasonal variation in the river is important for two reasons. During the spring and early summer, floods inundate large areas that are dry most of the year. The density of invertebrates is reduced at this time because the population is dispersed over a larger area. Normal sampling points are inaccessible during high water. During these periods it is necessary to sample temporarily submerged areas that often provide marginal habitat and are poorly colonized.

Seasonal variation is also important because of the different life histories of the various species. Some species produce only one generation per year (univoltine), and others produce several (multivoltine). Many of the univoltine insects have eggs or early stage immature forms that diapause (become physiologically inactive) for relatively long periods, and the eggs and early stages of the nymphs or larvae are too small to be captured by macroinvertebrate collecting tools. After the period of inactivity, the eggs hatch, or the nymphs resume activity and grow rapidly to a size that is again collectable with macroinvertebrate sampling devices (Hynes 1970). Gaufin and Tarzwell (1952) illustrated this phenomenon by showing that most species of stoneflies and caddisflies are absent in collections taken during the summer. This is evident in Traverella albertana in the White River. This large, colorful mayfly nymph constituted 12 percent of all the mayfly nymphs captured in October 1974 but were absent from collections in February, April, and June 1975. It reappeared as small nymphs in July and constituted almost 33 percent of the samples in September 1975. This is partly responsible for the great fluctuations in numbers and biomass that many investigators have found throughout the year (Hynes 1960). The inactive period allows insects to avoid unsuitable environmental conditions and interspecific competition. In the White River, mayfly nymphs are predominant in the summer and autumn, and stoneflies are predominant in winter and spring. The temporal separation reduces competition, since they have similar habitat requirements.

The population densities of macroinvertebrates in the White River fluctuate. Populations appear to peak in September. At this time riffles are the most productive areas, but clumping occurs within, and between, the riffles. Habitats that are superficially identical have very different population densities: Square-foot Surber samples (0.093 m^2) have averaged from 13.4 organisms in April to 145 in late September. The average of all Surber samples taken to date is 645 organisms per m^2 (60 organisms per ft^2). Ekman dredge samples (0.023 m^2 or 0.25 ft^2) have ranged from 0 to 8,261 organisms per m^2 (0 to 760 organisms per ft^2). Those with the highest populations usually contained only one species, either chironomid larvae or worms.

Substrate

Aquatic invertebrates can be loosely classified on the basis of their habitat preference as either riffle dwellers or silt dwellers. The first group inhabits the riffles and other shallow areas where the bottom is mostly stone.

Their most important environmental requirements are a solid substrate and well aerated water. The group consists mainly of immature mayflies, stoneflies, and caddisflies, but includes some worms and the larvae of dipterans and beetles. Riffle-dwelling and rock-dwelling invertebrates are often considered the most important group because they are prominent in the diet of many game fishes (Usinger 1971).

In the White River the riffle community is dominated by mayfly nymphs most of the year. *Rhithrogena undulata*, *Heptagenia elegantula*, *Pseudocleoen turbidum* (species not confirmed), and several other species are present throughout the year. Instars of the nymphs range through a continuum from very small to those near maturity. Other species appear seasonally, including *Traverella albertana*, *Dactylobaetis cepheus* (species not confirmed), *Lachlania saskatchewanensis*, *Ephoron album*, and *Chorterpes albiannulata*. Most of the seasonal genera appear as discreet generations whose nymphs are all approximately the same size. Mayfly nymph abundance appears to reach the maximum in August and early September, decline somewhat through mortality, then drop rapidly with the emergence of *Traverella albertana* during mid to late September. Great numbers of *T. albertana* and *H. elegantula* emerged during late September, 1975. A total of 16 mayfly species have been collected from the White River (Table IV-45). Baumann et al. (1975) reported densities of up to 5,052 per m^2 (470 per ft^2), an extremely dense population indicative of productive conditions. The highest density encountered so far during this baseline study was 3,475 per m^2 (323 per ft^2). Composite Surber sample data are shown in Table IV-45.

Stoneflies have many of the characteristics of mayflies. They are most abundant in the riffles and shallow rapids where dissolved oxygen (D.O.) and algae are plentiful. Although stonefly nymphs are not found in samples taken during the summer, they are no doubt present as eggs or nymphs small enough to escape collection with standard macroinvertebrate sampling tools.

The most common species, *Isogenoides colubrinus* and *Oemopteryx fosketti*, appear in samples from the White River from October through May (approximately). These species are apparently quiescent until the water temperature falls to 10°C or 15°C (50°F or 59°F). During the week of February 10, 1975, *O. fosketti* emerged. The river was mostly ice covered at this time, and the air and water temperatures were near 0°C (32°F). The insects emerged onto the ice and crept across snow to the river banks.

TABLE IV-45

AQUATIC INVERTEBRATE DATA

Surber Samples	Ave.No. Organisms							
Sample Date	(ft^2)	(m^2)	S^2 (1)	S(2)	No. Samples Analyzed	No. Required(3)	CL(4)	Diversity(5) Index
October, 1974	22.7	244	382.7	19.6	16	132	71%	1.90
April, 1975	13.4	144	132.9	11.5	19	130.7	74%	1.89
July, 1975	4.6	49	36.2	6.1	17	308.6	58%	1.01
Sept., 1975	144.7	1,557	7,966	89.3	25	63.5	84%	2.37
Ekman Samples	(1/4 ft^2)	(m^2)						
Nov., 1974	87	3,741	2,247	47.4	8	105	64%	N/A
April, 1975	11.9	512	107.5	10.4	8(6)	147.5	60%	N/A
July, 1975	8.6	370	144.8	12.0	5	459.8	4%	N/A
Sept., 1975	2.1	90	6.6	2.6	15	271.5	67%	N/A

---

(1) Sample Variance.
(2) Standard Deviation.
(3) Number of samples required to estimate true mean within 25% at a 90% level of statistical confidence
(4) Confidence level for the number of samples analyzed
(5) Shannon Weaver diversity index.
(6) Nine samples were analyzed. One, from a residual pool, was not considered in statistical analysis.

Stonefly population levels are usually low. The highest detected to date was approximately 139 per m^2 (13 per ft^2) during April 1975. Populations are probably more dense during January, but they are difficult to quantify because of ice cover and river conditions.

The other major group of riffle-dwelling organisms in the White River are caddis larvae. The only significant populations are Hydropsyche sp., Leptocella sp. and Brachycentrus sp. Hydropsyche are present all year, and Leptocella are present during spring and summer. Caddis larvae population levels have ranged from near 0 to 792 per m^2 (0 to 74 per ft^2).

The second invertebrate group occurs in soft-bottom areas where the substrate is silt and detritus. In the White River this group is composed mainly of dipteran larvae and worms that live within, rather than upon, the substrate. Tubificid worms (Limnodrilus claparedianus) and immature dipterans (Chironomidae) are the most common soft bottom, or silt-dwelling, invertebrates. The worms and the midge larvae are both able to exist in areas where D.O. concentrations are less than 1 part per million (ppm). This gives these organisms a competitive advantage over organisms that require higher levels of D.O. Although L. claparedianus appear frequently in river samples, they prefer the soft bottom areas of backwaters and stagnant pools, where density may reach over 2,140 per m^2 (200 per ft^2). Chironomid-larvae habitat varies according to the different species. Some appear to prefer silt that is low in organic content and others prefer areas that are rich in detritus. Some of the species also occur in riffle areas. The maximum population of 7,062 per m^2 (660 per ft^2) occurred at Station F-1 during November 1974. Invertebrate data from soft bottom areas are also shown in Table IV-45.

Hemipterans form a third invertebrate group that is more or less independent of bottom conditions. They live on the water surface (water treaders and water striders) or are free swimmers (back-swimmers and water boatmen). Hemipterans are usually found in quiet pools or backwaters.

The most significant invertebrate populations in Evacuation Creek are larvae of the dipteran families Simuliidae and Chironomidae. The species (Simulium sp. and Crictopus sp.) have similar habitat requirements and do not occur at the same time. The larvae attach to pebble-sized shale particles in the streambed and filter food materials from the current. The chironomids have reached estimated population levels of 10,000 per m^2 (930 per ft^2) and simuliids, up to 25,000 per m^2 (2,320 per ft^2).

Other intermittently important invertebrates in Evacuation Creek are water striders (Gerris sp.) and small dydtiscid beetles (Hydroporus sp. and Agabus sp.). Callibaetis mayfly nymphs and larvae of limnephilid caddisflies were present in 1974, but did not appear in 1975.

Some investigators feel that the absence of certain invertebrates provides as much information about stream conditions as their presence (Ellis 1937; Hynes 1960). Two classes of invertebrates--crustaceans and mollusks--are conspicuously absent from the White River and Evacuation Creek.

Crustaceans and mollusks are generally scarce in the Rocky Mountain states, but certain groups of each are often common. In the Crustacea, amphipods (side-swimmers) are widespread in the region, and certain species of crayfish are common. The molluscan fauna is generally impoverished, but species of snails and clams are common (Pennak 1963). Pennak (1963) proposes several reasons for the absence of certain species in the region, including exclusion by geographic barriers and elimination by siltation. He reported that sections he has studied in the upper White River in Colorado are also devoid of crustaceans and mollusks.

Water Quality

Diversity indices are often used to evaluate the quality of an environment. Relatively undisturbed environments usually support communities with a wide variety of species, with no individual species in overwhelming abundance (Weber 1973). Diversity indices of organisms taken from the White River with Surber samples have averaged between 1.89 and 2.37 in a range from 0 (1 species) to 3.13 (18 species). Wilhm (1970) found that diversity indices in "unpolluted" water averaged between 3 and 4. The term "unpolluted" is somewhat ambiguous, since streams can become "polluted" from natural conditions.

Madsen (1935) graded productivity of streams according to the average numbers of bottom organisms. He graded streams with less than 1,076 organisms per m^2 as "poor," and those with 1,076 to 2,152 per m^2 as "rich." Fishery researchers have used this system for many years (Pennak 1974).

Prior to the field study of September 1975, data indicated that the White River was quite unproductive: Surber data showed well under 1,076 organisms per m^2. Surber data from September averaged 1,566 organisms per m^2, which is average under the Madsen system. Baumann et al. (1975) found over

6,000 organisms per m^2 near the White River bridge (Station F-3), indicating an extremely productive system. Pennak (1974) sampled the White River above and below the confluence of Piceance Creek in Colorado. He found an average of 1,048 organisms per m^2 and rated productivity poor.

There are no mollusks or crustaceans in the White River, even though its water quality is thought generally suitable (Hart and Fuller 1974). Turbidity, unstable banks, paucity of aquatic plants (macrophytes), and in the case of clams, low populations of suitable host fish for the parasitic larvae, are among the possible reasons for their absence.

Although it is outside the study area, a sample was collected from Ashley Creek at the U.S. Highway 40 bridge east of Vernal, Utah. Amphipods and snails (Physa sp, determination not confirmed) were abundant in the collection. Water quality data from Ashley Creek are not available for comparison with streams of the study area, but visual observation of the stream suggests that transparency is normally greater than that of the White River or Evacuation Creek. The extremely productive Ashley Creek shows signs of organic enrichment, probably from Vernal wastewater.

The variation in these figures indicates that many factors should be considered before basing a stream classification on bottom-fauna density; this is clearly indicated by data presented in earlier quarterly reports, in which White River invertebrate fauna have ranged from scarce to abundant, depending on where, and more important, when, they are measured.

f. Fisheries

The White River is the only significant fish habitat in the vicinity of the tracts. It does not support a significant sport fishery, and apparently for this reason it has received little attention prior to recent interest in oil shale development. Olsen (1973) reviewed literature pertaining to the White River fishery and interviewed investigators who had studied the stream. Since that time the river has been studied in the vicinity of the tracts by the Utah Division of Wildlife Resources (DWR) and by VTN (see Figure IV-30). Pettus (1974) studied the fishery of the White River and Pennak (1974) studied limnological conditions in the vicinity of the Piceance Creek Basin in Colorado.

Olsen (1973) reports that on five separate occasions in 1973 the DWR tried to collect fish from what were considered good habitats at the Highway 45 bridge near Bonanza and at the Mountain Fuel Supply bridge, about 32 km (20 mi) to the west. They used electrofishing, rotenone, explosives, and seines, but captured only a few flannelmouth suckers, red shiners, and roundtail chubs. In 1974 and 1975 the DWR were more successful with powerful electrofishing equipment, but seines, hoop nets, and minnow traps again were used with disappointing results. In addition to DWR samples, VTN has used minnow traps, seines, and a section of screen normally used for invertebrate sampling. The minnow traps have produced no results, the seines have been used successfully in backwaters, and the invertebrate screens have been used often to catch speckled dace in the riffles.

Eleven fish species have been collected from the White River in the study area (Tables IV-46 and IV-47). Pettus (1974) produced two additional species--the mottled sculpin (Cottus bairdi) and the mountain whitefish (Prosopium williamsoni). With the exception of one trout and one smallmouth bass captured near the Green River confluence, the fishes collected in Utah all reflect the character of the White River. All are adapted to existence in warm, turbid waters, and most of the endemic species possess morphological characteristics that suit them for an environment with fast water and unstable bottom conditions (Deacon and Minckley 1974). Within the river, each species can find suitable habitat in the fast water of the rapids or in the quieter pools and eddies. Suckers (Catostomus latipinnis and C. discobulus) are the dominant fishes of the project area in terms of biomass, and red shiners are the most abundant numerically. The presence of brown trout and smallmouth bass from the Ouray area should be considered accidental. Although trout occur in upstream reaches of the White River (Pettus 1974), they are apparently absent from the study area because of high water temperatures during the summer.

Bluehead and flannelmouth suckers are more plentiful in the project area than downstream. This is probably because the rapids and fast water common in the upper portions give way to smooth water with reduced current velocities at lower elevations.

The most abundant fish in the collections is the red shiner (Notropis lutrensis). It is an introduced species, as are fathead minnows, carp, and channel catfish (Sigler and Miller 1963). The red shiner was apparently unknown in Utah in 1963, since it was not listed by Sigler and Miller in The Fishes of Utah. Its abundance indicates that the fish is well adapted to conditions in the White River. The introduction of exotic species may have a profound effect on endemic species (Deacon and Minckley 1974), and may be partly responsible for reverses suffered by many of the rare species.

TABLE IV-46

FISHES COLLECTED FROM THE WHITE RIVER (1975)

Taxa	Stations Hells Hole Canyon	Bonanza Bridge	Southam Canyon	Asphalt Ridge	Bitter Creek Confluence	Mountain Fuel Bridge	East Boundary Indian Reservation	Bridge Near Ouray	Total
Pimephales promelas Fathead Minnow	0	0	0	0	1	0	0	0	1
Notropis lutrensis Red Shiner	7	0	4	5	30	29	11	55	141
Rhinichthys osculus Speckled Dace	38	14	14	12	29	9	13	6	136
Cyprinus carpio Carp	0	0	0	0	3	0	0	0	3
Gila robusta robusta Roundtail Chub	1	0	3	3	0	0	1	0	8
Catostomus latipinnis Flannelmouth Sucker	8	3	6	10	9	0	1	0	37
Pantosteus dolphinus Bluehead Sucker	3	3	14	3	0	0	1	0	24
Ictalurus punctatus Channel Catfish	2	0	1	0	1	3	2	3	12
Ictalurus melas Black Bullhead	0	0	0	1	2	0	0	0	3
Micropterus dolomieui Smallmouth Bass	0	0	0	0	0	0	0	1	1
Total	59	20	42	34	75	41	29	65	365

Data from Utah Division of Wildlife Resources

TABLE IV-47

FISHES COLLECTED FROM THE WHITE RIVER (1974)

	Stations								
Taxa	Hells Hole Canyon	Bonanza Bridge	Southam Canyon	Asphalt Ridge	Bitter Creek Confluence	Mountain Fuel Bridge	East Boundary Indian Reservation	Bridge Near Ouray	Total
Pimephales promelas Fathead Minnow	0	0	61	0	3	0	0		64
Notropis lutrensis Red Shiner	5	16	0	14	379	277	4	160	855
Rhinichthys osculus Speckled Dace	4	10	33	30	47	15	5	16	160
Cyprinus carpio Carp	0	1	0	0	1	0	3	4	9
Gila robusta robusta Roundtail Chub	0	2	1	1	22	0	2	0	28
Catostomus latipinnis Flannelmouth Sucker	10	26	43	27	38	7	2	0	153
Pantosteus delphinus Bluehead Sucker	2	2	2	14	1	0	0	1	22
Ictalurus punctatus Channel Catfish	0	0	0	0	0	0	0	21	21
Salmo trutta Brown Trout	0	0	0	0	0	0	0	1	1
Total	21	57	140	86	491	299	16	203	1,313

Data from Utah Division of Wildlife Resources

The fishery of the Colorado River system is almost unique in the number of endemic species, probably because of the area's geologic history (Holden and Stalnaker 1970). Many of the fishes, including the threatened species, were formerly considered abundant throughout their range. Ichthyologists who have studied the decline of the affected species generally agree that the decline is at least partially due to the chain of high dams that have been built on the Colorado system (Vanicek and Kramer 1969; Holden and Stalnaker 1970). Water is released from the bottom of the deep, thermally stratified reservoirs, and below the dam river sections that were once warm and turbid become clear and cold. Fish species adapted to pre-dam conditions have been replaced mostly by introduced populations of rainbow trout.

Various workers have suggested that four threatened, or potentially threatened, fish species could occur in the White River: the Colorado squawfish (*Pteichocheilus lucius*) and the humpback chub (*Gila cypha*), both listed as endangered on the U.S. Fish and Wildlife list of threatened species; the bonytail chub (*Gila elegans*); and the humpback sucker (*Xyrauchen texanus*). The latter two are not on the official list of threatened species but will probably be included in future publications (Wydoski, pers. comm.).

None of the endangered or potentially threatened species are known to occur in the White River. Sigler and Miller (1963) refer to humpback chubs that were supposedly captured near Bonanza; however, the catch is not documented or recorded in known technical publications (c.f. Olsen 1973). Over 1,300 specimens were collected in 1974 and an additional 365 were collected by the Utah Division of Wildlife Resources and the VTN aquatic biologist. None of these fishes were endangered or potentially threatened species (Crosby, pers. comm). All of the threatened species have been collected from the Green River between Dinosaur National Monument and Ouray, Utah (Vanicek et al. 1970; Holden and Stalnaker 1975). Since the White River fulfills most of the habitat requirements of the fish, it is still possible that they could occur; therefore, sampling will be continued with trammel nets, as approved by the Utah DWR.

4. CONCLUSIONS

The physical and chemical conditions in the White River and Evacuation Creek fluctuate widely. Because the White River is supported by a large watershed, it fluctuates predictably; Evacuation Creek, supported by a small watershed, responds to local storms that are unpredictable. Productivity in the White River apparently is regulated by turbidity, changes in water level, and temperature, whereas productivity in Evacuation Creek is limited by intermittent flow and alkalinity. The limited data available indicate that chlorophyll production is low in the White River and low to moderate in Evacuation Creek.

Aquatic macrophytes are virtually absent from the study area, probably because aquatic vegetation is limited by turbidity and fluctuating water levels. Periphyton productivity fluctuates with the seasons. Because phytoplankton is derived almost exclusively from periphyton, seasonal fluctuations in phytoplankton concentrations generally relate to periphyton abundance. Plankton cell counts from the White River fluctuate seasonally from 7,400 cells per liter to 78,500 cells per liter. Productivity is low during most of the year and is high when snow runoff recedes in July or August. When Evacuation Creek is low and clear, it is productive for periphyton and plankton. Thunderstorm-generated spates scour away most periphyton, plankton, and invertebrates.

Invertebrate populations in the White River are of moderate density and diversity. Density measured by Surber samples has averaged 645 organisms per m^2 (60 organisms per ft^2), indicating low overall productivity. In autumn, several genera of mayflies are near maturity, and macroinvertebrate populations reach levels characteristic of productive streams.

Mayflies are the most important group during summer and autumn, and stoneflies become important during winter and spring. The Shannon-Weaver diversity indices are moderately low, with averages ranging from 1.89 to 2.37. The dominance of detritus feeding invertebrates rather than autotrophs suggests that the primary energy input to the river system may be from terrestrial runoff. This is substantiated by the high ratios of biomass to pigment in periphyton samples.

The population densities of local fishes have not been established. The species present are typical of streams of this type and region and include such species as flannelmouth suckers, red shiners, and fathead minnows.

5. WORK SCHEDULED

The sampling and analysis schedules used the first year will be continued the second year, depending on weather and discharge rates.

E. MICROBIOLOGY

1. OBJECTIVES

The microbiology study is being conducted to estimate the numbers of micro-organisms and to measure their biochemical activities in the soils. Establishing a baseline for these organisms is important because their activities are the primary factor in detritus and litter decomposition and mineral cycling.

The independent variables in the system are the soil, the vegetation type, and the time of the year. The dependent variables are the numbers of aerobic and anaerobic bacteria, streptomycetes, fungi; and proteolytic activity, dehydrogenase activity, respiration (CO_2 release), ATP concentration, nitrogen fixation, ammonification, total nitrogen, ammonium nitrate, and organic carbon concentrations, and seasonal fluctuations.

2. METHODOLOGY

Four sampling stations were established near soil survey pits (Figure IV-6). Station 39 is near pit 39, where the dominant vegetation is *Atriplex tridentata* and *Artemisia nova*. Station J is some distance from pit 50 in a juniper area, where the dominant vegetation is *Artemisia nova* and *Juniperus osteosperma*. Station 55 R is 5 m from the White River bank, which has mixed riparian vegetation. Station 58 is dominated by *Artemisia nova* and *Sarcobatus vermiculatus*.

Sample designations are as follows:

39 - 1	Surface - 3 cm
39 - 2	5-20 cm
39 - 3	40-50 cm
50 J - I - 1	Surface 3 cm, interspace
50 J - I - 2	5-20 cm, interspace
50 J - L	Surface litter, beneath *J. monosperma* canopy
50 J - C - 1	2-4 cm, beneath canopy
50 J - C - 2	4-15 cm, beneath canopy
55 R - 1	Surface - 3 cm
55 R - 2	5-20 cm
55 R - 3	40-50 cm

58 I - 1	Surface 3 cm, interspace
58 I - 2	5-20 cm, interspace
58 I - 3	40-50 cm, Interspace

58 C - 1	Surface 3 cm, beneath *A. nova* canopy
58 C - 2	5-20 cm, beneath canopy
58 C - 3	40-50 cm, beneath canopy

Each sample is ground in the laboratory or particles larger than 3 mm in diameter are removed. The sample is then stored at 4°C (40°F) until examined.

The numbers of bacteria, streptomycetes, and fungi in the soils are determined by standard microbiological plating methods. Proteolytic activity is based on a protein (gelatin) hydrolysis by the soil enzyme. The total dehydrogenase activity is measured and defined as the ability of the soil biota to reduce triphenyltetrazolium chloride to the respective formazan. Soil respiration is measured by its CO_2 release, a process dependent on soil moisture conditions and the soil water potential measurements (i.e., measurement of available water, not total water content). ATP measurement (adenosine triphosphate) is based on the luciferin-luciferase reaction. Nitrogen fixation is determined with a gas chromatograph by the acetylene reduction method. The organic carbon content is determined by a soil's digestion of potassium dichromate. Ammonium, nitrate, and total nitrogen contents are determined by using appropriate Kjeldahl digestion systems and spectrophotometry.

3. SUMMARY OF RESULTS

a. Numbers of Microorganisms

The average number of microorganisms per gram of soil remained relatively consistent throughout all seasons (Table IV-48), as expected because of the steady, low nutrient influx. In July and August, the numbers decreased slightly in the surface layer, with an equivalent rise in numbers at the lower levels. This is predictable for arid, virgin soils, since over the dryer summer months moisture is retained better at the lower depths than at the surface.

b. Dehydrogenase Activity

Dehydrogenase activity in soil is measured to obtain correlative information about the biological activities of microbial

TABLE IV-48

AVERAGE MICROBIAL NUMBERS FOR INDIVIDUAL SITES

Site	Aerobic Bacteria	Anaerobic Bacteria	Streptomycetes	Fungi
March 28, 1975				
39	10.7×10^5	1.62×10^5	3.29×10^5	1.01×10^4
50 J-I	5.1×10^6	6.25×10^5	16.5×10^5	9.9×10^3
50 J-C	2.3×10^6	5.5×10^4	6.5×10^5	3.75×10^4
55 R	10.8×10^6	1.11×10^5	4.5×10^5	9.6×10^3
58 I	3.5×10^6	4.9×10^4	7.9×10^5	2.0×10^4
58 C	5.0×10^6	5.1×10^5	7.5×10^5	1.7×10^4
50 J-L	7.2×10^7	2.5×10^5	3.6×10^6	9.0×10^5
April 25, 1975				
39	14.7×10^5	2.06×10^4	8.03×10^5	7.9×10^3
50 J-I	4.8×10^6	6.8×10^4	2.4×10^6	1.1×10^4
50 J-C	1.6×10^6	6.0×10^4	8.5×10^5	1.6×10^4
55 R	2.2×10^6	1.3×10^3	5.6×10^5	1.1×10^4
58 I	1.9×10^6	5.3×10^3	9.4×10^5	1.4×10^4
May 16, 1975				
39	1.6×10^6	2.6×10^3	6.5×10^5	1.7×10^4
50 J-C	4.6×10^6	7.0×10^3	2.6×10^6	3.8×10^4
50 J-I	4.1×10^6	3.5×10^4	3.1×10^6	8.8×10^3
55 R	3.7×10^6	2.0×10^3	7.2×10^5	1.3×10^4
58 I	2.2×10^6	6.7×10^4	1.2×10^6	7.5×10^3

TABLE IV-48 (Cont.)

Site	Aerobic Bacteria	Anaerobic Bacteria	Streptomycetes	Fungi
May 27, 1975				
39	10.6×10^5	4.7×10^3	4.5×10^5	3.7×10^3
50 J-C	9.4×10^6	3.0×10^3	3.8×10^6	2.4×10^4
50 J-I	6.5×10^6	1.08×10^5	3.3×10^6	2.0×10^4
55 R	5.2×10^6	7.3×10^3	7.2×10^5	1.7×10^4
58 I	2.0×10^6	3.7×10^4	1.0×10^6	1.1×10^4
July 2, 1975				
39	1.7×10^6	1.6×10^4	5.2×10^5	6.8×10^3
50 J-C	3.7×10^6	1.9×10^4	1.4×10^6	1.2×10^4
50 J-I	5.6×10^6	1.5×10^4	1.5×10^6	5.6×10^3
55 R	5.9×10^6	7.3×10^3	4.6×10^5	2.6×10^4
58 I	1.8×10^6	3.0×10^3	7.5×10^5	1.1×10^4
58 C	2.4×10^6	1.5×10^4	7.1×10^5	7.6×10^3
August 8, 1975				
39	1.2×10^6	1.17×10^3	7.9×10^5	1.2×10^4
50 J-I	3.1×10^6	1.3×10^4	1.6×10^6	1.1×10^4
50 J-C	3.8×10^7	4.4×10^4	2.0×10^6	4.8×10^4
55 R	2.4×10^6	5.6×10^3	5.0×10^5	1.4×10^4
58 C	1.8×10^6	2.5×10^4	6.3×10^5	2.2×10^4
58 I	8.9×10^5	1.3×10^3	5.3×10^5	9.5×10^3
50 J-L	3.3×10^6	5×10^2	6.0×10^5	2.3×10^5

TABLE IV-48 (Cont.)

Site	Aerobic Bacteria	Anaerobic Bacteria	Streptomycetes	Fungi
		September 12, 1975		
39	1.6×10^6	7.45×10^3	7.5×10^5	1.15×10^4
50 J-I	7.4×10^6	1.1×10^4	4.0×10^6	2.1×10^4
50 J-C	9.9×10^6	3.7×10^4	2.96×10^6	3.0×10^4
55 R	9.1×10^5	4.3×10^3	1.7×10^5	9.6×10^3
58 I	2.6×10^6	3.9×10^3	7.5×10^5	5.3×10^3
58 C	1.9×10^6	1.7×10^4	7.0×10^5	2.06×10^4
50 J-L	1.7×10^7	9.9×10^4	1.0×10^6	6.5×10^4
		October 13, 1975		
39	7.7×10^5	1.8×10^3	3.0×10^5	1.07×10^4
50 J-I	4.1×10^6	1.3×10^4	2.5×10^6	2.8×10^4
50 J-C	2.1×10^6	7.2×10^3	1.6×10^6	2.6×10^4
55 R	2.3×10^6	9.0×10^3	4.2×10^5	2.4×10^4
58 I	1.2×10^6	1.05×10^4	7.8×10^5	9.0×10^3
		November 6, 1975		
39	1.21×10^6	4.7×10^3	4.8×10^5	4.2×10^3
50 J-I	3.3×10^6	1.0×10^3	2.5×10^6	2.8×10^4
50 J-C	1.7×10^6	1.2×10^4	1.0×10^6	2.7×10^4
55 R	4.95×10^6	6.9×10^4	7.0×10^6	1.1×10^5
58 I	7.9×10^5	3.3×10^3	3.8×10^5	1.38×10^4
58 C	1.2×10^5	1.39×10^4	3.6×10^5	1.67×10^4
50 J-L	1.4×10^6	2.4×10^4	4.4×10^5	2.5×10^5

populations in soil rather than about the enzyme itself. Fertile, cultivated soils exhibit high dehydrogenase activity, whereas saline and high pH soils exhibit almost no activity. The determination of dehydrogenase activity is based on the ability of the soil to reduce triphenyltetrazolium chloride to the respective formazan. Hence, the rate of formazan formation is indicative of total biological activity.

In general, all soils exhibited low activities (Table IV-49), decreasing from late March through mid-May and fluctuating at low levels (below 0.10 mg x 10^{-3} formazan/ml) until early August. A pronounced increase in activity at sites 50 J-I and 50 J-C was observed throughout the rest of the summer and fall, with a particularly notable rise in September. In mid-October through early November, activity increased substantially at site 55 R also, whereas a steady decrease and equilibrium ensued (at very low levels) from late March until mid-September. Activity increased at sites 58 I and 58 C in September and early November and decreased to low levels in October.

Activity levels appeared higher at sites under canopies. Overall, site 50 J-C showed the most activity. Activity at site 55 R, after low levels throughout spring and summer, increased in late summer and rose to its highest level in November.

c. Proteolytic Activity

The hydrolysis of proteins by soil microorganisms is a necessary step in the nitrogen cycle of soils. The amount of proteolytic activity, therefore, indicates the ability of a particular soil to hydrolyze protein. Proteolytic activity is related to moisture content and varies during the vegetative period. In addition, activity also decreases with depth in profile (Table IV-49).

Proteolytic activity throughout the period observed was lowest at site 39 and increased steadily from late March to its peak in mid-May. Activity decreased from May throughout summer and fall and reached its lowest point in early November, although it rose slightly in August.

Site 50 J-C showed the most proteolytic activity, peaking in September. The activity level dropped off substantially in July, increased steadily to September, dropped in October, and rose to a high level in late fall. Proteolytic activity at site 50 J-I rose from March to its high point in late May and dropped to its low point in early July as a result

TABLE IV-49

AVERAGES OF VALUES OF MICROBIAL ACTIVITY MEASUREMENTS FOR INDIVIDUAL SITES

Site	Percent Water Content	pH	Percent Hydrolysis Proteolysis	Dehydrogenase mg formazan/g	Respiration CO_2 µm/g/min	H_2O Potential -bar	NH_4-N µg/g	N_2-Fix g N/ha/day	NO_3-N µg/g	C:N
March 28, 1975										
39	12.97	8.6	1.83	.022	18.87	-33.57	16.93	89.41	.833	8.2
50 J-L	58.40	7.7	59.0	.740	202.90	-14.30	349.27	-	.500	18.9
50 J-C	17.60	8.0	37.50	.129	39.10	-27.10	98.17	299.31	.900	11.6
50 J-I	18.30	8.0	15.75	.069	27.85	-13.50	54.27	174.77	1.30	9.1
55 R	16.30	8.05	6.60	.059	34.67	-17.17	21.80	65.44	1.03	12.4
58 I	13.40	8.25	10.0	.048	20.47	-15.00	20.12	44.07	1.95	8.7
58 C	14.07	8.43	19.0	.064	24.17	-10.33	18.65	142.68	1.20	10.0
April 25, 1975										
39	14.10	8.27	8.00	.006	20.53	- 7.67	23.31	23.30	4.83	9.0
50 J-C	14.55	7.95	17.00	.091	20.40	-13.65	66.99	21.40	16.50	9.6
50 J-I	17.35	8.05	32.25	.052	19.05	-10.60	79.27	59.02	12.50	9.1
55 R	11.40	8.33	16.33	.011	17.47	- 9.90	18.30	128.93	7.30	16.5
58 I	10.43	8.70	15.83	.013	14.83	-12.40	20.52	81.02	5.60	10.7
May 16, 1975										
39	11.09	8.23	9.60	.015	3.93	-11.25	13.11		1.90	8.9
50 J-C-1	10.76	7.80	26.00	.080	7.40	- 7.00	70.44		1.20	11.8
50 J-I	9.95	8.05	17.50	.045	6.50	- 9.25	77.34		3.00	9.8
55 R	11.45	8.10	11.13	.017	11.00	-10.17	26.70		1.47	18.3
58 I	10.43	8.30	8.00	.011	2.70	- 8.50	16.27		1.73	8.5

TABLE IV-49 (Cont.)

Site	Percent Water Content	pH	Percent Hydrolysis Proteolysis	Dehydrogenase mg formazan/g	Respiration CO_2 µm/g/min	H_2O Potential -bar	NH_4-N µg/g	N_2-Fix g N/ha/day	NO_3-N µg/g	C:N
May 27, 1975										
39	12.20	8.67	4.67	.012	18.97	-19.50		222.30	.933	13.3
50 J-C-1	15.10	8.30	29.00	.015	21.70	-10.80		7.61	.500	24.9
50 J-I	12.65	8.15	24.25	.040	20.30	-10.15		-	2.30	11.0
55 R	20.17	8.30	14.67	.030	17.53	-10.67		249.47	.467	18.5
58 I	13.06	8.70	9.17	.020	7.70	-15.10		31.62	.767	8.1
July 2, 1975										
39	4.40	8.83	5.00	.047	4.40	-48.43	18.44	72.12	.800	9.0
50 J-C-1	7.50	8.45	15.50	.050	3.30	-14.00	86.33	5.24	.800	9.1
50 J-I-1	5.40	8.60	11.00	.010	4.40	-49.00	71.49	227.14	1.50	8.9
55 R	22.13	8.60	9.67	.057	23.70	- 2.67	49.35	123.50	.333	14.6
58 C	2.76	9.83	10.67	.057	1.37	-46.00	23.26	110.53	.600	12.0
58 I	2.67	9.60	6.50	.010	2.17	-76.00	22.99	49.23	2.10	11.5
August 8, 1975										
39	5.05	8.63	6.00	.017	5.40	-54.50			.967	4.6
50 J-I	5.16	8.60	11.33	.065	4.25	-77.70			.800	9.9
50 J-C	6.41	8.45	25.75	.090	6.25	-26.65			.500	10.9
55 R	10.66	8.60	11.67	.015	12.43	- 4.60			.500	13.6
58 C	4.09	8.83	6.00	.005	9.10	-60.83			1.067	12.4
58 I	2.87	9.37	14.67	.042	4.77	-68.50			1.967	10.6
50 J-L	6.05	8.00	66.00	.110	5.40	-177.20				

TABLE IV-49 (Cont.)

Site	Percent Water Content	pH	Percent Hydrolysis Proteolysis	Dehydrogenase mg formazan/g	Respiration CO_2 μm/g/min	H_2O Potential -bar	NH_4-N μg/g	N_2-Fix g N/ha/day	NO_3-N μg/g	C:N
September 12, 1975										
39	5.06	8.43	5.87	.088	5.27	-236.17			1.70	12.0
50 J-I	14.20	8.00	19.0	.421	9.91	- 57.50			2.10	13.6
50 J-C	10.44	8.15	36.0	.775	17.87	-114.70			3.20	32.9
55 R	5.18	8.18	7.97	.112	3.56	-178.20			.233	17.0
58 I	4.35	9.22	9.03	.026	2.01	-219.53			1.170	11.7
58 C	3.14	9.37	15.10	.126	2.61	-292.60			3.230	13.5
50 J-L	31.17	7.95	62.20	1.223	36.61	- 32.30				53.2
October 13, 1975										
39	9.17		4.03	.042	1.61	- 72.57			.966	8.9
50 J-I	9.99		13.00	.040	5.88	-156.71			2.10	9.7
50 J-C	14.95		23.50	.256	6.33	- 18.20			.800	13.9
55 R	7.23		10.77	.066	6.32	-191.51			.466	13.1
58 I	7.79		4.77	.008	0	-170.46			1.133	7.7
November 6, 1975										
39	7.72	8.73	1.23	.020	12.15	-166.13				
50 J-I	13.99	7.40	30.50	.220	14.12	-227.40				
50 J-C	8.66	7.50	16.80	.477	6.68	- 23.60				
55 R	13.48	8.20	8.55	.463	10.91	- 86.35				
58 I	8.94	7.53	8.67	.023	1.34	-170.73				
58 C	8.04	9.13	22.33	.099	6.18	- 83.69				
50 J-C-L	9.83	7.10	51.00	.454	18.14	-228.20				

of a substantial drop to 11 percent hydrolysis. A steady increase through the summer ended as activity decreased in mid-October and rose again to approximately 17 percent in November.

Sites 58 I and 55 R followed the same general pattern of proteolytic activity as that at site 50 J-C. Activity at Site 58 C decreased generally from March to early July and rose steadily throughout summer and fall (Table IV-49).

d. Respiration

The rate of CO_2 production (respiration) in soil is an indirect method of determining a soil's biological activity and organic-matter decomposition rates. The respiration rates are shown in Table IV-49. The rates recorded for March at all sites indicated that the greatest activity was in the early spring. All sites followed the same pattern in the spring: their rates dropped steadily through mid-May, rose abruptly in late May, and declined (dropped to their respective low points) in early July. The exception was site 55 R, which increased substantially in early July and dropped to its low point in September. Site 55 R rates then increased steadily through fall. Sites 50 J-C and 50 J-I showed the same general pattern during spring and summer. The soil respiration at site 50 J-C leveled off in the fall while that at site 50 J-I rose steadily. Overall, the values at site 50 J-C remained consistently higher than those of its interspace counterpart, site 50 J-I.

Following the same trends, the respiration rates rose at sites 58 I and 58 C from July to August and declined in September; after that, rates at site 58 C increased throughout the fall. Conversely, the respiration rates at site 58 I continued to decline, rising only slightly in November. In all cases, activity decreased with depth and was generally higher in canopy soils than in interspace soils.

e. Water Potential and Water Content

The negative water potential, expressed in bars of atmospheric pressure (Table IV-49), is a useful method of relating soil moistures to activities occurring within the soil by analyzing seasonal changes in biological activities where moisture is always a factor. As previously noted, the increased biological activity observed in September corresponds with lower water potentials.

As expected, higher potentials (more negative values) were generally observed during the dryer summer months, with greater potentials in spring and fall. The actual water content, shown as the percentage of soil weight (Table IV-49), is not expected necessarily to correlate with biological activities, and the values are shown here for record only.

f. Nitrification Potential

The nitrification potential was measured by the perfusion method, and for the March 28 samples, perfusates were analyzed for ammonium, nitrite, and nitrate. In this procedure, soils are at optimum conditions for the nitrifying population in the soil to oxidize added ammonium.

Results of tests (Table IV-50) indicate these soils tend to follow the pattern of nitrification potential found in arid, desert soils, and a long lag period of 16 to 18 days is necessary to build up the nitrifying population.

g. ATP Concentration

ATP, adenosine triphosphate, is a ubiquitous compound present in all living organisms. It has been established that the average amount of ATP in a bacterial cell is 5×10^{-11} μg. Several million bacteria, for example, in addition to fungi and streptomycetes, contribute to the total ATP concentration in soil. ATP represents a certain form of energy available to the cell and therefore also represents biological activity. The results correlated well with dehydrogenase activity (Table IV-51).

h. Nitrate Values

The decomposition of proteins and other nitrogenous organic substances causes ammonium to form in the soil. Under favorable conditions, ammonium is rapidly oxidized to nitrite and then to nitrate. Most of the nitrate is assimilated by plants or is denitrified (lost to the atmosphere as N_2 gas). Thus, the concentration of nitrate indicates the nitrogen available to plants and the net rate results of nitrification and denitrification.

As expected, nitrate concentrations were low at all sites. The concentrations increased only slightly in April and May (Table IV-49).

TABLE IV-50

NITRIFICATION POTENTIAL

µg N/dry g goil - Surface Samples Only

Sample	(April 25, 1975)		(May 16, 1975)*		(May 27, 1975)		(July 2, 1975)	
	NH_4^+	$NO_2^-+NO_3^-$	NH_4^+	$NO_2^-+NO_3^-$	NH_4^+	$NO_2^-+NO_3^-$	NH_4^+	$NO_2^-+NO_3^-$
39	142	9	29	23	80	0	75	138
50 J-C	6	31	0	25	52	14	89	74
50 J-I	0	21	0	0	0	28	74	7
55 R	0	106	0	13	9	98	2	138
58 I	47	0	0	7	29	54	96	6
58 C	-	-	-	-	-	-	0	67

Sample	(August 8, 1975)		(Sept. 12, 1975)		(Oct. 13, 1975)	
	NH_4^+	$NO_2^-+NO_3^-$	NH_4^+	$NO_2^-+NO_3^-$	NH_4^+	$NO_2^-+NO_3^-$
39	26	56	179	44	49	25
50 J-C	150	0	196	10	105	19
50 J-I	155	10	191	49	87	6
55 R	19	19	131	0	1	41
58 I	71	4	65	0	32	23
58 C	118	20	100	0	-	-

*Incubated at 30°C

Garden Soil Comparisons

NH_4^+	$NO_2^-+NO_3^-$
38	55

TABLE IV-51

ATP CONCENTRATION AVERAGES

µg ATP/dry g soil

Sample	March 28, 1975	April 25, 1975	May 16, 1975	May 27, 1975	July 2, 1975
39	1.04	1.18	1.16	.7233	1.04
50 J-C	1.49	1.18	1.21	1.66	1.17
50 J-I	1.18	1.30	1.21	1.275	1.03
55 R	1.05	1.29	1.21	1.08	-
58 I	1.15	1.19	1.21	1.23	-
58 C	1.06	-	-	-	-

i. Organic Carbon and Nitrogen

Soil organic carbon and nitrogen values represent an accumulation of partially decayed and partially synthesized plant and animal residues, essentially the sole source of soil nitrogen. Decomposition rates are best expressed as a carbon:nitrogen ratio. The low values of the carbon:nitrogen ratio (see Table IV-49) recorded during sampling indicated efficient decomposition of available plant residue. The ratio values were generally 8 to 10 throughout the year. The exception was early fall (September 12), when all sites showed a general increase. Particularly high ratios were recorded at sites 50 J-C and 50 J-L, because of the litter and plant residue accumulation at the surface; characteristically, these sites had higher values throughout all sampling periods. Carbon:nitrogen ratios were higher at canopy sites than at interspace sites because of the accumulation of undecomposed plant material.

i. Nitrogen Fixation

Expressed as g of N fixed per hectare per day, nitrogen fixation (N_2) varied with each site and ranged from 5.24 to 299.31. A decrease in N_2 fixation was noted from March to April for all sites except 55 R and 58 I, which showed a slight increase. A large rise in N_2 fixation was recorded again at site 55 R in late May (Table IV-49). Fixation at site 39 also increased significantly from late April to late May. Fixation at site 50 J-C continued to drop through the spring and early summer. A low of 5.24 was recorded July 2 for all sites.

k. Total Ammonium Nitrogen

The values given in Table IV-49 are expressed as μg of nitrogen bound in ammonia per gram of soil. As expected, the highest values were recorded in litter samples, with sites 50 J-C and 50 J-I showing higher concentrations overall; site 39 showed the lowest values in all dates sampled. In comparison with cultivated control soil, the concentrations of the samples were low, typical for this area and arid soils in general.

4. CONCLUSIONS

The microbial and biochemical activities recorded at the sites were usual for soils in similar arid western areas. The activities were strongly dependent on moisture and therefore on the season. The strong allelopathic (inhibition by the presence of plants) effects usually present in other arid areas were not prevalent on the tracts; especially, juniper did not appear to inhibit microbiological activities.

As in other ecosystems, the nutrient supply to plants, especially nitrogen, is very dependent on microbial activities. The annual detritus and litter fall decomposes quickly and there is not much accumulation of soil organic matter, except under the juniper canopies. The biological activities, however, are limited to the periods when the soil is wet, that is, in spring and fall. Although elevated temperatures are conducive to more biological activity, high temperatures (summer) in this ecosystem are associated with dry soils and thus with less activity.

5. WORK SCHEDULED

Since this report is based only on the observations of a single growing season (March-November 1975), the study will be extended on the same observational and experimental basis through 1976 to obtain a two-season average with a statistical analysis made on microbiological activity for the final report.

F. ECOLOGICAL INTERRELATIONSHIPS

Natural ecosystems such as those of the tracts comprise a variety of abiotic and biotic components. The abiotic elements include the substrate and meteorological factors, and the biotic elements include plants, animals, and microorganisms. All of these components interact in a dynamic way to produce a functionally integrated ecosystem. In this section the structure and operation of the tracts' ecosystem will be described, and some of the more interesting and important interrelationships among components will be discussed.

1. DESERT ECOSYSTEMS

The tracts are part of the Great Basin desert, the largest desert in North America. Biologists characterize deserts (arid lands) as areas of low annual precipitation, high incident radiation, relatively low soil carbon and nitrogen levels, and high meteorological variability. Much of the biological activity in deserts is hidden from view because most of the plant and animal biomass is underground and many animals are nocturnal. Some inconspicuous activities and processes such as detritus food chains and biogeochemical cycles are of particular importance in deserts.

There are misconceptions about the structure and function of desert ecosystems that are only now being dispelled by research. Deserts have been thought of as relatively simple ecosystems; it is now known that a desert's response to disturbance is difficult to predict because of the widely fluctuating meteorological conditions and the plasticity of desert organisms. Desert ecosystems have also been considered fragile; although it is true that arid environments recover slowly from some types of disturbances, it is also true that desert organisms exhibit resilience and adaptability. Most biologists consider the relative aridity and relatively low levels of soil carbon and nitrogen in deserts to be chronic stressors of organisms living there. This assumption may be more a product of man's preoccupation with agronomic land use and for his own physical comfort than of empiric inquiry, since scientists have yet to show that sagebrush are less fit for their environment than oak trees are for their environment.

2. COMPONENTS OF THE TRACTS' ECOSYSTEMS

a. Climate

The climate of the tracts, like that of the Great Basin desert generally, is characterized by low precipitation and wide temperature ranges. Precipitation occurs for the most part during late fall, winter, and early spring and results in a consistent annual recharge of soil moisture. Localized thunderstorms, which usually last less than one hour, provide virtually the only rainfall during the hot, dry summer and fall but contribute little moisture for net primary production. In 1975 the annual precipitation on the tracts averaged 20 cm to 28 cm (8 in. to 11 in.), increasing by about 7.5 cm (3 in.) for each 300-m (1,000-ft) rise in elevation. About 57 percent of the mean annual precipitation occurred as snow and 43 percent occurred as rain.

Diurnal temperature means in 1975 ranged from 15°C to 28°C (59°F to 82°F) in July and -8°C to 0°C (18°F to 32°F) in February. Occasionally, the daily maxima was 33°C (91°F) in July and the daily minima was -14°C (7°F) in February. Since 1968 the highest diurnal temperature was about 38°C (100°F) recorded in July or August, and the lowest nocturnal temperature was -25°C (-31°F) recorded in early January.

The microclimates on the tracts vary widely from place to place because of differences in topography, vegetative cover, altitude, and kinds of storms during the growing season. The influence of terrain and plant cover can be appreciated when the difference between surface temperature, soil moisture, and wind velocity beneath a shrub on a north slope and on a bare southwest slope are considered. The interaction between abiotic components and vegetation in creating microclimates that differ markedly from the general climate of the tracts is largely responsible for the biotic diversity of the tracts.

The elevational differences contribute to microclimate variation by creating cold air drainage and temperature inversions. A surface-based inversion attributable to nocturnal ground-surface cooling usually occurs in the morning and disappears by the afternoon. The inversion in winter, spring, and fall is about twice as strong as in summer. The temperature difference between riparian areas and adjacent upland areas, which are 200 m to 300 m (656 ft to 984 ft) higher, may be as much as 10°C (18°F). Elevation on the tracts varies from about 1,465 m to 1,800 m (4,807 ft to 5,906 ft), and the average annual maximum temperature probably occurs at about 1,700 m (5,578 ft).

Rainfall during the growing season tends to be sporadic and unpredictable in time, space, and intensity. A thunderstorm such as one that occurred in July 1975 may deposit 2 cm to 3 cm (0.8 in. to 1.2 in.) of rain in a few hours, cause severe erosion, initiate germination in annual plants, and stimulate an increase in microorganism populations while leaving areas several kilometers away completely dry.

b. Soils

The substrate of the tracts consists of exposed bedrock, broken pieces of rock of various sizes, and soil. The percent coverage of each is uncertain, but the non-soil components of the substrate are known to be substantial. Most of the upland soils are shallow and poor: they are low in organic material and retain moisture poorly. The only soils of any depth are those under the larger plants, in valley bottoms, and along the water courses. These lowland soils have higher infiltration rates than those of upland soils.

Several factors combine to preclude the formation of deep soils in most areas. Combinations of occasional, intense rainstorms, annual spring run-off, wind, and hilly topography of sandstone bedrock result in heavy erosion. The erosion, increased to an unknown degree by livestock, tends to cause continual sloughing of soil in the interstices, or bare areas, between the larger plants, especially on the steeper slopes. The condition perpetuates itself, since few plants that could reduce erosion can grow in the eroding areas. From an agronomic point of view, the lack of moisture and the poor soils must be considered major limiting factors to the potential biotic productivity of the tracts.

In large measure the soil characteristics dictate the kind of plant community an area will support. Animal communities are more reflective of the plants that directly or indirectly support them than they are of the soils; however, some of the animals on the tracts are directly dependent on soil type and soil depth for their existence. Kangaroo rats, for example, are restricted to loose, sandy soil like that found along the broader washes of the tracts. The shallow, porous soils on hillsides, especially in the interstices between shrubs, support few burrowing animals, and the environment is often too dry for significant microbial activity. Bedrock presents a physical barrier to invertebrates such as harvester ants and termites, which normally establish large subsurface colonies. Vertebrate poikilotherms such as lizards and heterotherms such as ground squirrels which hibernate cannot exist in shallow soils that prevent them from burrowing below the frost line.

c. Microbiology

In all natural ecosystems, microorganisms have a major role in cycling nutrients either by breaking down organic material into chemical elements and making them available to plants or by transforming nutrients into a form usable by plants. If these processes are slowed or halted, plant growth is reduced or stopped. Perhaps the most critical of the nutrient cycles is that of nitrogen.

Three major microbial processes contribute plant nitrogen on the tracts. The first process is nitrogen fixation by bacteria that occur near the soil surface and in the presence of moisture. The second process is nitrogen fixation by microorganisms in the rhizosphere (root zone). Although this phenomenon has long been associated with legumes, recent research indicates that fixation may occur generally in the root zones of desert soils. The third process is nitrogen recycling within the ecosystem. Microorganisms transform the nitrogen bound in dead animal and plant tissues to nitrates, which are then available to plants. On the tracts this cycle is probably the most susceptible to disruption. Anything that interferes with the microbes, with the moisture necessary for their activity, or with the detritus they decompose tends to break or slow the cycle. Although it is certain that each of these processes contributes nitrogen to the soil of the tracts, the relative contribution of each is unknown. The amount of soil nitrogen present is low compared with nitrogen levels in agricultural fields but is about average for desert soils. Since little is known about the nitrogen requirements of native desert plants, little can be said about the adequacy of plant nitrogen on the tracts.

There is relatively little carbon (humus) in the soils of the tracts. Soil carbon is important because it is the energy source for microbial populations. With carbon in short supply, the action of microbes in the decomposition process and in the production of nitrates is reduced. The C/N ratios in the soils of the tracts range from 4.6:1 to 53.2:1, which may suggest that nitrate production is limited by the scarcity of carbon. Whether or not the low level of soil carbon limits net productivity on the tracts is not known; it is certain, however, that the interrelationships between factors that control the pathways and rates of biogeochemical cycles, with which microbes are inexorably bound, are among the most important on the tracts.

d. Plants

The tracts are situated in a salt-desert shrub community that grades into pinyon-juniper in the more rugged terrain. The plant communities on the tracts form a patchwork of four vegetation types with a large amount of ecotone between types. Patches of riparian vegetation occur in the bottomlands along the White River, and shadscale is prevalent on the rolling hills above the river. The dominant plants of the higher valleys and along the dry washes are sagebrush and greasewood. At the highest elevations and on some of the steeper slopes, juniper is the dominant plant.

Most of the larger plants on the tracts serve a function beyond their normal role as autotrophs. On slopes of anything more than a few degrees, each shrub and tree forms a barrier to the movement of soil particles and litter by wind and water erosion, and the build-up of material improves the moisture-holding characteristics of the soil around the plants. Algal crusts, which contribute soil nitrogen to the system, exist on the ground beneath some of the plants. Invertebrates and microorganisms flourish in the moist litter and soil, forming detritus food chains important in soil genesis, and the enriched area beneath the large plants supports small vertebrates. In this way the biogeochemical cycles are complete within the microhabitat created by the plants.

The more a plant benefits from the microhabitat it helps to create and protect, the more the plant contributes to the habitat. Thus, a shrub that begins as a small barrier to erosion becomes the center of a small, relatively self-contained biological community complete with functions that modify the microclimate, mechanically protect the microhabitat, cycle nutrients, and transform energy.

Most of the vegetation biomass of the tracts is shrubs and pinyon-juniper. These plants are widely spaced, as indicated by the 85 percent bare ground on the tracts. For the most part the interstices between plants have shallow soil, low organic content, poor moisture retention, and low biological activity. In the more eroded interstices, roots tend to be confined to fractures in the bedrock. Thus, the small islands of biological activity beneath the trees and shrub canopies are essentially the units of ecological function on the tracts; and as such, their number, size, and condition are keys to the status of the ecological community. Any factor that changes the number, size, or condition of these islands will constitute an important impact on the local environment.

In addition to being widely spaced, the shrub and tree micro-islands are also fairly uniformly spaced on the tracts. There are perhaps three major factors influencing their dispersion. The first is competition in the interstices for water and nutrients. The second is the interdependency of the plants and the microhabitats beneath the plants, which imposes biotic and abiotic limits on how large an island can be and how close one can be to another. The third factor influencing dispersion is sheep grazing. Sheep in a shrub community move in the interstices from shrub to shrub as they move along. This promotes erosion and destroys any small plants in the interstices, however, the micro-islands themselves are protected from sheep by the shrubs.

e. Invertebrates

Invertebrates are important in most natural ecosystems at all consumer trophic levels. It is beyond the scope of the baseline study, and indeed of most studies, to determine the biomass and significance of even some of the common taxa on the tracts; however, it is important to note that according to recent research, invertebrates have a much greater impact upon ecosystems than do native vertebrates. Invertebrate carnivores and herbivores probably cycle more energy and material through the ecosystem per unit time than do their vertebrate counterparts.

Desert invertebrates have an especially important function in detritus food chains because they initially process dead material, a vital first step in the cycling of nutrients necessary for plant growth. Termites, harvester ants, and spring-tails are some of the more common organisms on the tracts. Without the activity of these invertebrates, most litter would not be available to decomposer organisms, and important biogeochemical cycles would be arrested. Disruption of the detritus food chain on the tracts would most certainly decrease the amount of nitrogen available to plants.

Desert invertebrates are also important in the diets of many vertebrates. On the tracts, many vertebrates eat invertebrates; and amphibians, lizards, snakes, and birds are largely insectivorous. Many herbivores and granivores, such as juncos and ground squirrels, change to a diet of invertebrates during the summer.

Some invertebrates have unique relationships with other segments of the community. On the tracts insect pollinators are necessary for reproduction in some plants. There are also many invertebrate pest species that carry several types of ectoparasites. Biting midges, mosquitoes, and deer flies are common. The latter two organisms may cause some mammals, such as deer, to move away from the riparian habitat during the day. Grasshoppers and sagebrush defoliators are numerous in some areas of the Great Basin desert and have a considerable impact on the vegetation; however, the tracts may not have enough sagebrush and may be too diverse to support heavy outbreaks of these or other defoliating insects.

f. Vertebrates

A diverse vertebrate fauna inhabits the tracts as a result of the variety of habitats created by the topography and the patchy mixture of vegetation types. Beaver, whiptail lizards, and pinyon jays can be found within a few hundred meters of each other, and the number of birds per hectare on the tracts are higher than in more typical desert shrub communities.

Recent desert studies indicate that native vertebrates are usually the least important component of the ecosystem from a biological standpoint; however, human disturbance is more easily noticed at the vertebrate level because of the smaller number of animals concerned. In most cases, it is difficult to measure the impact of most vertebrates species, and thus it probably is not worth the effort to measure how much environmental change would occur if deer, fence lizards, or horned larks were removed. It is also fairly safe to assume that (1) vertebrate granivores collectively do not so deplete the seed reserves that plant propagation is curtailed, (2) native herbivores do not significantly decrease the net productivity of plants, and (3) insectivores do not significantly limit insect populations over the long term. Native vertebrates are more apt to have an impact on like vertebrates than on other components of the biotic community. Thus, a fence lizard has more influence upon other individuals of its species (conspecifics) or upon other lizards than it has upon insect populations.

Some vertebrate populations have considerable impact upon the environment of the tracts or have interesting interrelationships with other elements of the biotic community. Three examples--beaver, coyotes, and livestock--are discussed below:

Beaver

A small population of bank beaver live along the White River. Their pattern of habitat use is to make a den in the river bank and feed on shrubs and small trees in an ever-widening circle around the den. When the distance between the food supply and the den becomes too great for their convenience or safety, they move to another stretch of river and repeat the process. After ten or more years, beaver may return to the original area. The effect of this pattern of exploitation is to cycle secondary plant succession between early and intermediate seral stages. Beaver tend to delay or prevent the development of mature plant communities along the river, which benefits cattle and most wildlife. Beaver may also increase the instability of river banks and may increase the chance that the river will alter its channel.

Coyotes

Coyotes are the most important large vertebrate carnivore on the tracts. Their population density on the tracts is unknown, but it is probably fairly stable because of their natural prey base. Most of the year the coyotes prey on animals whose populations do not fluctuate greatly from year to year. There are no jackrabbits or microtine rodents on the tracts, which in some areas strongly influence coyote numbers with their widely fluctuating populations. Coyotes on the tracts do not usually follow sheep populations from area to area; instead, the sheep become merely an additional food source. Control programs in the area may temporarily reduce coyote populations but probably result in immigration from surrounding areas and increased reproductive rates of the remaining coyotes.

Livestock

Livestock undoubtedly have a greater impact on the environment of the tracts than any other vertebrate group, including humans. Cattle remove and trample significant amounts of riparian vegetation annually; however, since cattle are restricted to patches of riparian habitat along the White River, their impact over the total area is small.

Sheep graze extensively over most of the tracts. They tend to move in the spaces between plants and to stop at each palatable plant to eat, which removes some of the plant material and decreases the litter available to the detritus food chains. This may or may not decrease the vigor of the plants and the mini-communities beneath them, depending on the amount of plant material removed. Sheep movement tends to accelerate erosion in the plant interstices, and it may increase the size of well-established biotic islands and prevent new biotic islands from forming.

Although the impact of sheep on the tracts has not been documented, it appears that sheep have shifted the historic equilibrium between the factors responsible for the biotic islands and the factors responsible for the interstices. They have probably increased the shrub micro-island effect by (1) increasing the number of large islands, although reducing their vigor; (2) decreasing the number of small islands; and (3) increasing the amount of bare ground between the shrubs. The removal of sheep might increase the vigor of the shrub micro-islands now existing, but probably would not significantly alter the current equilibrium for many years.

g. Aquatic Systems

Although aquatic ecosystems within deserts occupy a much smaller part of the area than in other types of communities, evidence indicates that their importance is disproportionately large. Water in the desert--whether it be a temporary pool, an intermittent stream, or a river--is the site of intense biological activity and provides the medium for a well-defined biotic community. Many terrestrial vertebrates need regular access to free water, and consequently their dispersal patterns are governed by its availability; also, numerous terrestrial invertebrates and amphibians depend on surface water, since their larvae are aquatic. Ground water is equally important because its consistent flow to permanent water sources regulates the development of a unique flora with a concomitant fauna. Perhaps the most important aspect of desert water sources is that they are often the focal point of human activity and its accompanying impacts.

The White River is the largest aquatic ecosystem on the tracts. Like all large aquatic systems, it is a relatively stable environment. Water volume, temperature, nutrient availability, and light penetration change little from day to day, and most of the changes that do occur follow predictable cyclical events. The most important of these events is spring runoff. At this time, the quantity of water increases dramatically, and the silt load of the river, which is high at any time, increases accordingly. The silt scours the riverbed and reduces light penetration, which tends to decrease primary production by removing aquatic plants from the river bottom and by reducing photosynthesis. Primary production is highest in fall, when low flow and reduced silt loads result in better light penetration.

The most significant interrelationship between the river and other components of the tracts is the riparian habitat. Silt deposited from the river provides the substrate for the habitat, and water from the river maintains it. Thus, the aquatic system indirectly supports cattle, many migratory birds, trees, and all the other organisms unique to the riparian environment.

The abiotic and biotic components of this ecosystem are interrelated in complex and dynamic cycles. The components are virtually innumerable, and only a few of the simpler cycles have been empirically determined. The "word model" for the final report will be an elaboration of this first year's "word model" and will be based on two years of data and a better understanding of the physical and biological functioning on the tracts.

GLOSSARY

Allelopathic: the detrimental influence of a plant upon another, caused by products of metabolism.

Amphibian: any of a class (Amphibia) of vertebrates including frogs, toads, and salamanders that usually begin life in water as tadpoles with gills and later develop lungs; they have body temperatures approximating ambient temperatures and are scaleless.

Arthropod: any of a phylum of invertebrates including crutaceans, insects, spiders, centipedes, and millipedes that have jointed appendages and hard exoskeletons.

A.U.M.: (Animal unit month) - the amount of forage on an acre of land required to support one cow or five sheep for one month.

Autotrophs: organisms which are capable of producing organic substances from inorganic materials by means of energy received from outside of the organisms, e.g., plants with chlorophyll and certain bacteria.

Avifauna: collectively, the birds characteristics of a particular area.

Biota: collective flora and fauna of any particular area.

Canopy: the uppermost layer consisting of crowns of trees or shrubs in a forest or woodland.

Cap-chur gun: a device used to propel a drug dart using compressed gas as a propellant.

Causality: the existence of regularities which control natural phenomena.

Community: collectively, all of the populations inhabiting a common environment and interacting with each other.

Ecosystem: collectively, all populations in a community, plus the associated environmental factors.

Ecotone: a transition line or strip of vegetation between two communities which has characteristics of both kinds of neighboring vegetation as well as characteristics of its own.

Edge: that area between two communities, c.f. ecotone.

Endangered species: a legal classification of those species in danger of extinction throughout all or a significant portion of their range.

Ephemeral: short-lived existence.

Fauna: collectively, the animal life of any particular area or of any particular past time.

Flora: collectively, the plant life of any particular area or of any particular past time.

Habitat: place where an animal or plant normally lives, often characterized by a dominant plant form or physical characteristic.

Heterotherms: refers to homeotherms that at times behave like poikilotherms and lose their powers of thermo regulation.

Holometabolous: refers to invertebrates that undergo complete metamorphosis, during which there are four stages; the egg, larva, pupa, and image or adult.

Homeotherms: an animal which is able to maintain the temperature of its body at an approximate constant level independent of the surrounding medium.

Hypae: filaments or thread-like structure of a fungus.

Invertebrate: collectively, all animals without a vertebral column.

Irruptive: tending to irrupt, to undergo a sudden upsurge in numbers.

Larva: general term for any independent, active, immature stage of an animal which is morphologically quite unlike the adult; grows into an adult by a complicated metamorphosis in most cases.

Macrophytes: macroscopic aquatic plants, generally those that are visible without optical magnification.

Metamorphosed: a marked structural change in an animal during postembryonic development.

Micro-environment: a distinctive unit of a larger environment.

Nahcolite: a white, monoclinic mineral consisting of natural sodium bicarbonate ($NaHCO_3$).

Phenology: the study of the periodic phenomena of animal and plant life and their relations to the weather and climate, e.g., the time of flowering in plants.

Phytoplankton: collectively, all those microscopic plants suspended in the water of aquatic habitats; includes algae and fungi.

Poikilotherms: animals that lack the capacity to control their body temperature which is approximately that of the environment.

Population: all of the individuals belonging to a single species occupying a particular area or space.

Primary production: assimilation (gross) or accumulation (net) of energy and nutrients by plants and other autotrophs.

Range: geographic area in which a particular organism, species, other taxon, or community occurs.

Reptile: any of a class (reptilia) of vertebrates including snakes, lizards, turtles, tortoises, etc.: they have body temperatures approximating ambient temperatures and are covered with scales or scutes.

Riparian: pertaining to the bank or shore of a river, lake or stream.

Species: the classification level of biological nomenclature which categorizes each group of related organisms potentially capable of interbreeding, the accepted level of classification to differentiate one specific type of organism from another (e.g. Ursus Americanus, the black bear, is differentiated as a separate species from Ursus horribilis, the grizzly bear).

Threatened species: those species which are likely to become endangered within the forseeable future throughout all or a significant portion of their range.

Zooplankton: collectively, all those animals suspended in the water of an aquatic habitat which are not independent of currents and water movements; most such organisms are microscopic and commonly include protozoans, rotifers, and small crustaceans.

REFERENCES

American Public Health Association. 1971. Standard methods for the examination of water and wastewater. American Public Health Assoc., Washington D.C. 13th ed.

Anderson, B. and A. H. Holmgren. 1969. Mountain plants of northeastern Utah. Utah State Univ. Extension Serv. Cir. 319. Utah State Univ., Logan, Utah.

Balph, D.F. 1973. Curlew Valley validation site report. *in* Desert biome research memorandum 73-1. Utah State Univ., Logan Utah.

Bauman, R.W., A.H. Gaufin, and R.N. Winget. 1975. Aquatic habitat evaluation of the White River, Uintah County, Utah. Prepared for Utah Div. of Wildlife Resources. Salt Lake City, Utah. (Draft copy).

Bormann, F.H., G.E. Likens, and J.S. Eaton. 1969. Biotic regulations of particulate and solution losses from a forest ecosystem. Bioscience 10:600-611.

Butcher, R.W., J. Longwell, and F.T.K. Pentelow. 1937. Survey of the River Tees III. Tech. Pap. Wat. Pollut. Res. (London).

Castrup, B.C. 1963. Vegetational changes of the Uinta Basin since settlement. M.S. Thesis, Brigham Young Univ. Provo, Utah.

Davenport, J.W., J.E. Bowns, and J.P. Workman. 1973. Assessment of sheep losses to coyotes--a problem to Utah sheepmen--a concern to Utah researchers. Utah State Univ. Ag. Exp. Sta. Res. Report 7. Utah State Univ., Logan, Utah.

Day, W.C. 1971. Ephemeroptera. *in* R.L. Usinger, ed. Aquatic insects of California. Univ. of California Press. Berkeley, California.

Deacon, James E. and W.L. Mickley. 1974. Desert fishes. *in* G.W. Brown, ed. Desert biology. Academic Press, New York.

Ellis, M.M. 1937. Detection and measurement of stream pollution. Bull. U.S. Bur. Fish. 48:365-437.

Fisher, S.G. and G.E. Likens. 1973. Energy flow in Bear Brook, New Hampshire: an integrative approach to stream ecosystem metabolism. Ecol. Mon. 43(4): 421-429.

Gaufin, A.R. and C.M. Tarzwell. 1952. Aquatic invertebrates as indicators of stream pollution. Public Health Rep. Wash. 67(1):57-64.

Graham, E.H. 1937. Botanical studies in the Uinta Basin of Utah and Colorado. Annals of the Carreigies Mus. 26:1-432.

Harper, Kimball, et. al. 1974. Summary of the research activities relating to undergraduate research participation. Grant No. Y001151 to the Brigham Young Univ. Dept. of Botany and Range Science. Brigham Young Univ., Provo, Utah.

Harrington, H.D. 1964. Manual of the plants of Colorado. 2nd ed. Sage Books, Denver.

Hart, C.W. Jr. and S.L.H. Fuller. 1974. Pollution ecology of freshwater invertebrates. Academic Press, New York.

Holden, P.B. and C.B. Stalnaker. 1970. Systematic studies of the Cyprinid genus Gila, in the upper Colorado River Basin. Copeia 1970(3):409-420.

Holden, P.B. and C.B. Stalnaker. 1975. Distribution and abundance of mainstream fishes at the middle and upper Colorado River Basins, 1967-1973. Trans. Amer. Fish. Soc. 104(2):217-231.

Holmgren, A.H. 1962. The vascular plants of the Dinosaur National Monument. Utah State Univ., Logan, Utah.

Hutchinson, G.E. 1967. A treatise on limnology. Vol. II. John Wiley and Sons, New York.

Hynes, H.B.N. 1960. The biology of polluted waters. Univ. of Toronto Press, Toronto.

Hynes, H.B.N. 1970. The ecology of running waters. Univ. of Toronto Press, Toronto.

Jennrich, R.I. and F.B. Turner. 1969. Measurement of noncircular home range. J. Theoret. Biol. 22:227-237.

Madsen, M.J. 1935. A biological survey of streams and lakes of Fort Apache and San Carlos Indian Reservations, Arizona. U.S. Bur. Fish., Washington D.C.

Needham, P.R. and Usinger, R.L. 1956. Variability in the macrofauna of a single riffle in Prosser Creek, California, as indicated by the Surber sampler. Hilgardia 24(14): 383-409.

Odum, E.P. 1963. Primary and secondary energy flow in relation to ecosystem structure. Congr. Al. 4:336-338.

Odum, E.P. 1969. The strategy of ecosystem development. Science 164:262-270.

Adum, E.P. 1971. Fundamentals of ecology. W.B. Sauneers Co., Philadelphia.

Olsen, P.F. 1973. Wildlife resources of the Utah Oil Shale Area. Utah State Dept. of Natural Resources, Div. of Wildlife Resources, Publ. No. 74-2. Salt Lake City, Utah.

Overton, W.S. 1965. A modification of the Schnable estimator to account for removal of animals from the population. J. Wildl. Mgmt. 29:392-395.

Pennak, R.W. 1963. Rocky Mountain states. in D.G. Frey, ed. Limnology of North America. Univ. of Wisconsin Press, Madison, Wisconsin.

Pennak, R.W. 1974. Regional oil shale study: Limnological status of streams, Piceance Creek Basin, Rio Blanco and Garfield Counties, Colorado. Prepared for the State of Colorado. Thorne Ecological Institute, Boulder, Colorado.

Pettus, D. 1974. Regional oil shale study: inventory and impact analysis of fishes, Piceance Creek Basin, Rio Blanco and Garfield Counties, Colorado. Prepared for the State of Colorado. Thorne Ecological Institute, Boulder, Colorado.

Powell, J.W. 1879. Report on the lands of the arid region of the United States with a more detailed account of the lands of Utah. 2nd ed. U.S. Govt. Printing Office, Washington, D.C.

Provasoli, L. 1969. Algal nutrition and eutrophication; in Eutrophication; causes, consequences, correctives. Nat. Acad. Sci. Washington, D.C.

Roughton, R.D. 1974. Relative indices of predator abundance in the western United States. U.S. Department of the Interior. Denver Wildlife Research Center, Denver, Colorado.

Scagel, R.F., et al. 1967. An evolutionary history of the plant kingdom. Wadsworth Publ., Belmont, California.

Schnable, Z.E. 1938. Estimation of the total fish population of a lake. Amer. Math. Monthly 45:348-352.

Sigler, W.F. and R.R. Miller. 1963. Fishes of Utah. Utah State Department of Fish and Game, Salt Lake City, Utah.

Slack, K.V., et al. 1974. Methods for collecting and analysis of aquatic biological and microbiological samples. U.S. Govt. Printing Office, Washington, D.C.

Stebbins, R.C. 1966. A field guide to western reptiles and amphibians. Houghton Mifflin Co., Boston, Massachusetts.

Stoddard, L.A., et al. 1938. Range conditions in the Uinta Basin, Utah. Utah Agric. Exp. Sta. Bul. 283. Utah State Univ., Logan, Utah.

United States Geological Survey. 1973. Water resources data for Utah, 1972. Part 1, surface water records. USGS Water Resources Division, Salt Lake City, Utah.

Usinger, R. L. 1971. Aquatic insects of California. Univ. of California Press, Berkeley, California.

Vanicek, C.D. and R.H. Kramer, 1969. Life history of the Colorado squawfish, *Pteichocheilus lucius*, and the Colorado chub, *Gila robusta*, in the Green River in Dinosaur National Monument, 1964-1966. Trans. Amer. Fish Soc. 98(2):193-208.

Vanick, C.D. 1970. Distribution of the Green River fishes in Utah and Colorado following closure of the Flaming Gorge Dam. The Southwestern Naturalist 14(3):297-B15.

Wagner, F.H. 1972. Coyotes and sheep. Forty-fourth faculty honor lecture. Utah State Univ., Logan, Utah.

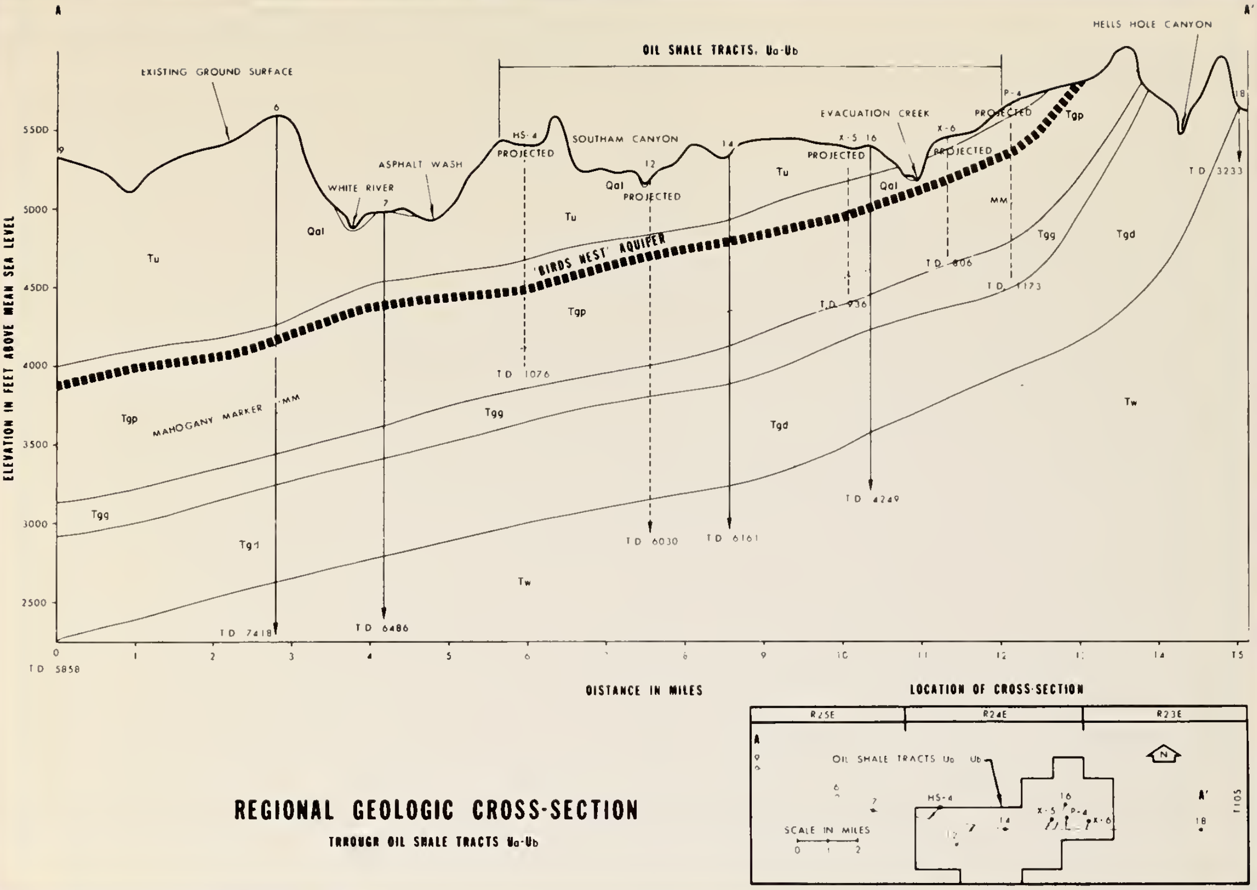
Warner, M.L., et al. 1974. An assessment methodology for the environmental impact of water resource projects. EPA 60015-74-016. Washington Environmental Research Center, Washington, D.C.

Weber, C.I., ed. 1973. Biological field and laboratory methods for measuring the quality of surface waters and effluents. EPA 67-/4-73-001. U.S. Govt. Printing Office, Washington, D.C.

Welch, P.S. 1948. Limnological methods. McGraw-Hill, New York.

Welsh, S.L. 1957. An ecological survey of the vegetation of the Dinosaur National Monument, Utah. M.S. Thesis, Brigham Young Univ., Provo, Utah.

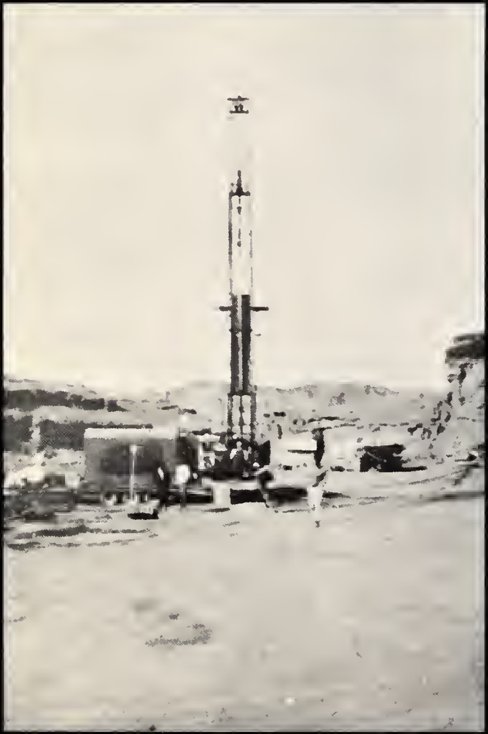
Wilhm, J.L. 1970. Range of diversity index in benthic macroinvertebrate populations. Jour. Water Poll. Con. Fed. 42 (5):R221-R-224.



REGIONAL GEOLOGIC CROSS-SECTION

THROUGH OIL SHALE TRACTS Ua-Ub

V SOILS & GEOLOGY



V. SOILS AND GEOLOGY

A. SOILS

1. OBJECTIVES

Soils on the tracts were studied to define and document soil conditions prior to development. These data are essential as a basis for planning and designing the mining and processing facilities.

2. METHODOLOGY

The soils were surveyed according to the standard procedures of the Soil Conservation Service (SCS) and the Utah Agricultural Experiment Station, Department of Soils and Biometeorology. These procedures are given in recent soil survey reports (U. S. Dept. of Agriculture 1973) and will not be included in this report.

Prior to the study, a reconnaissance was conducted by stereoscopic study of aerial photographs and by on-site observations. Geologic maps of the area were studied to determine general relationships of parent materials to the soil types. The vegetation and relief were studied to determine their relationships to the soils.

The detailed survey was conducted by first selecting a map scale and aerial photographs. The photos were studied by stereoscope to determine the direction of traverses, which are made at right angles to the linear trends of the landscape. Selected areas were then excavated to expose the soil layers, or horizons, which generally extend from the surface down into the parent material. The sequences of these natural layers are described in detail according to methods and nomenclature of the Soil Conservation Service (U. S. Dept. of Agriculture, 1951).

While the survey was in progress, soil samples were collected at selected locations from each horizon for processing at the soil laboratory at Utah State University (USU). Comparisons of field data and analytical data obtained from the laboratory were the basis for naming the soil types.

3. SUMMARY OF RESULTS

a. Soil Survey

The soils were mapped according to their location on the tracts (Figure V-1). Each map unit represents one soil type or complexes of two or more soils so intermingled or small in extent that they cannot be shown separately. Each soil complex contains at least 75 percent of the two or more dominant soils, and the distribution and relative proportions are about the same in all units. The name of a soil complex consists of the names of the dominant soils joined by a hyphen. Because rock outcrop and bare rock surfaces are extensive in the area, some of the map units are complexes of soils and rock outcrop.

Nine different soils were identified on the site--A, As, B, Bs, Ds, E, F, N, W. The description of each one includes information on soil texture, thickness, underlying parent material, occurrence, elevation, vegetation, precipitation and temperature. A representative pedon (a block of soil considered typical of the soil type being discussed) is described for each horizon. Following the description of the representative pedon is information on soil use and hydrologic characteristics. The map units in which the particular soil dominates are described. The occurrence of the map unit, the percentage of the unit occupied by the dominant soil, the other important soils in the complex, and the slope angles of the unit are stated.

A Soils: The A soils consist of shallow channery loams. The soil depth ranges from about 30 cm to 50 cm (12 in. to 20 in.) and overlies bedrock of the Green River Formation. They occur in upland settings on 5 to 40 percent north-facing and east-facing slopes. A soils occur in association with B soils. B soils generally occur on south-facing and west-facing slopes at elevations ranging from about 1,590 m to 1,710 m (5,200 ft to 5,600 ft). The vegetation established on the A soils consists mainly of sagebrush and shadscale with scattered Indian ricegrass and bluebunch wheatgrass.

Average annual precipitation ranges from about 15 cm to 20 cm (6 in. to 8 in.), and the mean annual soil temperature ranges from about 4°C to 7°C (40°F to 45°F).

A representative pedon on a steep north-facing slope (about 30 percent slope) on the west side of Evacuation Creek Canyon, about 460 m (1,500 ft) south and about 180 m (600

LEGEND

A(1-5) - SHALLOW CHANNERY LOAMS, 3 TO 40 PERCENT SLOPES

As(1-5) - SHALLOW CHANNERY SANDY LOAMS, 5 TO 60 PERCENT SLOPES

B(1-3) - SHALLOW CHANNERY AND FLAGGY LOAMS, 5 TO 40 PERCENT SLOPES

Bs(1-6)(R) - SHALLOW CHANNERY AND FLAGGY SANDY LOAMS, 10 TO 60 PERCENT SLOPES

Ds(D) - SANDY LOAMS, 5 TO 10 PERCENT SLOPES

E (EN) - DEEP LOAMS, 5 TO 10 PERCENT SLOPES

F (FR) - SHALLOW LOAMY SANDS, 3 TO 7 PERCENT SLOPES

N(NE, BD) - DEEP, MODERATELY FINE TEXTURED SOIL, 5 TO 10 PERCENT SLOPES

W - DEEP SILTY ALLUVIUM, 0 TO 2 PERCENT SLOPES

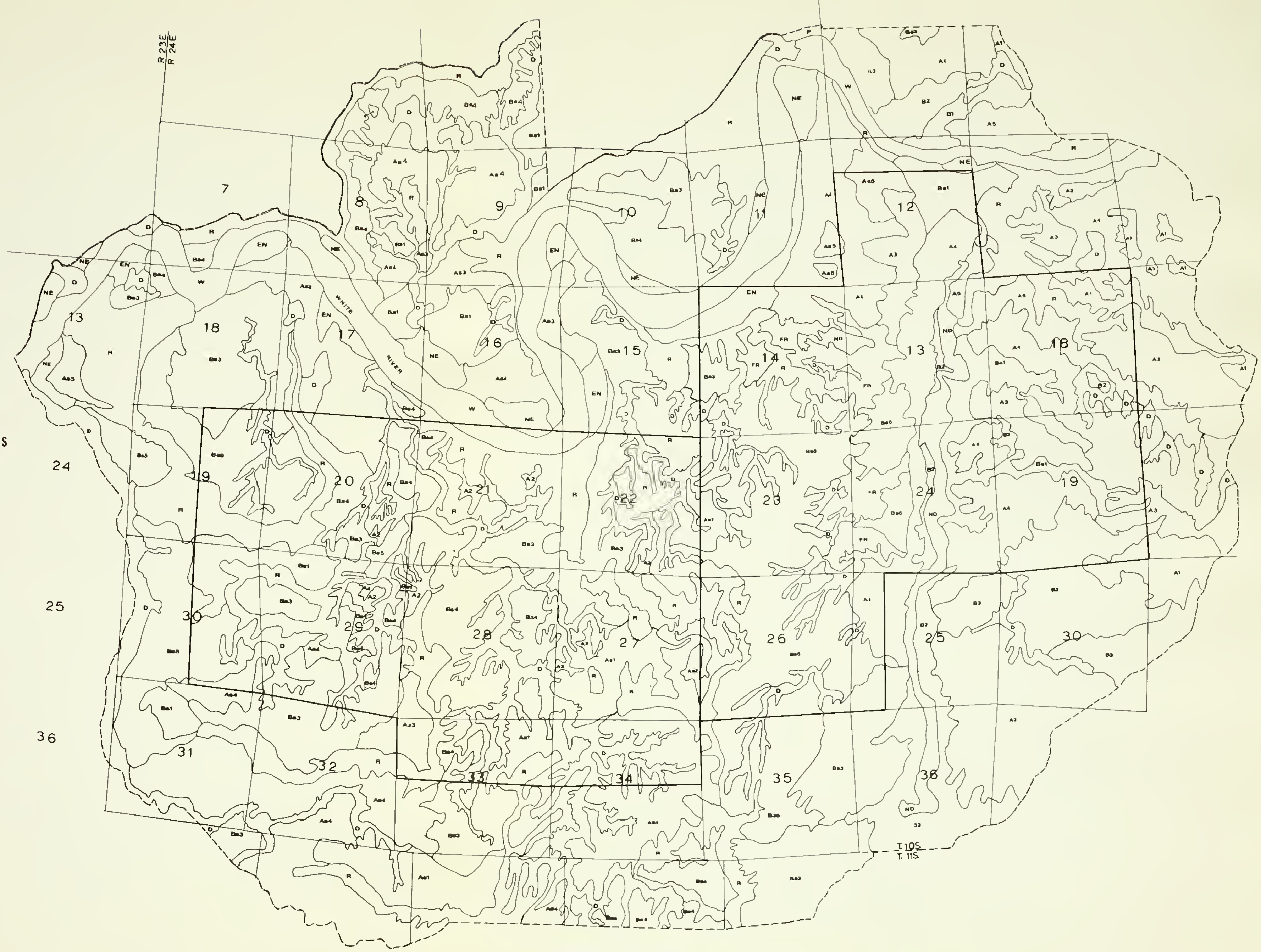


PHOTO MOSAIC; NOT TO SCALE

SOILS MAP
OIL SHALE TRACTS Ua, Ub AND CORRIDOR

NOVEMBER 1975

FIGURE V-1

ft) east of the North quarter corner of Section 13, T10S, R24E follows:

A_1	0 cm to 6 cm (0 in. to 2.4 in.)--pale brown (10YR6/3) channery loam; brown (10YR4/3) when moist; weak, fine, platy structure; slightly hard, friable, slightly sticky, and slightly plastic; moderately calcareous; moderately alkaline (pH 8.0); clear, smooth boundary.
C_1ca	6 cm to 20 cm (2.4 in. to 7.9 in.)--pale brown (10YR6/3) very channery loam; massive; slightly hard, friable, slightly sticky, and slightly plastic; plentiful fine roots; strongly calcareous; moderately alkaline (pH 8.3).
C_2ca	20 cm to 45 cm (7.9 in. to 17.7 in.)--very pale brown (10YR7/3), very flaggy loam; pale brown (10YR6/3) when moist; massive; slightly hard, friable, slightly sticky, and slightly plastic; abundant, very fine roots; strongly calcareous; strongly alkaline (pH 8.7); bedrock at 45 cm (18 in).
R	45 cm (17.7 in.)--bedrock of the Green River Formation.

The content of coarse fragments, channers, and flagstone is high throughout with numerous channers and flagstones on the surface. Estimates of the coarse fragment content is as follows: 0 cm to 6 cm (0 in. to 2.4 in.), 25 percent; 6 cm to 20 cm (2.4 in. to 7.9 in.), 50 percent; and 20 cm to 45 cm (7.9 in. to 17.7 in.), 80 percent, mainly flagstones. Lime coats the undersides of coarse fragments, and there are many hard lime pendants.

Vegetation supported by these soils is used for wildlife habitat and winter sheep grazing. Permeability is moderate, and runoff is medium to low. The hazard of erosion is moderate. This soil will hold from 2.5 cm to 5 cm (1.0 in. to 2.0 in.) of available water.

A Channery Loam, 10 to 20 percent slopes (A1): This mapping unit occurs on broad, convex ridge tops in a few small areas in the eastern part of the survey area and is associated mainly with areas of AC-BD complex. About 75 to 85 percent of the unit is A channery loam on 10 to 20 percent slopes. Inclusions are mainly A channery loam on 20 to 40 percent north-facing slopes and small areas of B channery loam on 20 to 40 percent slopes.

A Channery Loam, 3 to 8 percent slopes (A2) : This mapping unit occurs on nearly level to gently undulating mesa tops in the western part of the area, mainly in Southam Canyon, in isolated areas completely surrounded by very steep escarpments of Rockland - BsE complex. Bodies are irregular, generally long, and comparatively narrow. Vegetation is shadscale, black sage, rabbitbrush, needle grass, and curly grass. About 75 to 80 percent of this mapping unit is A channery loam on 3 to 8 percent slopes. Inclusions consist of B channery loam, B flaggy loam, and A flaggy loam. The very shallow B soils occur near the outer edges of the mesa tops.

AC-BD Complex, 10 to 40 percent slopes (A3): This mapping unit is moderately extensive. It occurs in the eastern part of the area in upland settings between Evacuation Creek and Hells Hole Canyon and is generally associated with the AD-BD complex, which is very similar except for slope gradient.

About 45 to 55 percent of the complex is A channery loam on 10 to 20 percent slopes. It occurs on broad convex ridges and gentle north-facing slopes; 25 to 30 percent is B channery loam on 20 to 40 percent steep south-facing slopes. Included with this unit are small areas of A channery loam on 20 to 40 percent slopes (AD) and D channery loam on 5 to 10 percent slopes in small drainageways.

AD-BD Complex, 20 to 40 percent slopes (A4): This mapping unit occurs extensively in the eastern part of the survey area, mainly east of Evacuation Creek Canyon. About 45 to 55 percent of the complex is A channery loam on 20 to 40 percent slopes, mainly north-facing; 25 to 30 percent is B channery loam on 20 to 40 percent south-facing slopes. Inclusions are A channery loam on 10 to 20 percent slopes on the broader ridge tops; D channery loam on 5 to 10 percent slopes in small drainageways; and rock outcrop on steep, south-facing slopes.

AB-BB Complex, 5 to 10 percent slopes (A5): This mapping unit occurs to a limited extent in the area east of Evacuation Creek Canyon. One area occurs northeast of the main road in Sections 18 and 20, T10S, R25E10. About 45 to 55 percent of the complex is A channery loam on 5 to 10 percent slopes; 30 to 35 percent is B channery loam on 5 to 10 percent slopes. Inclusions are mainly D channery loam on 5 to 10 percent slopes.

As Soils: As soils consist of shallow channery sandy loams. Soil depth ranges from about 30 cm to 50 cm (12 in. to 20 in.) and overlies bedrock of the Uinta Sandstone Formation. The soils occur in upland settings on 5 to 40 percent slopes. As soils are generally on long, north-facing slopes but also occur in other aspects. These soils occur in association with Bs soils, and most of the mapping units are complexes of both.

Elevations range from about 1,650 m to 1,770 m (5,400 ft to 5,800 ft). Vegetation consists mainly of sagebrush, juniper, shadscale, and yellowbrush. At the higher elevations pinyon pine occurs with the juniper. Average annual precipitation ranges from about 17 cm to 23 cm (7 in. to 9 in.), and the mean annual soil temperature ranges from about 5°C to 7°C (41°F to 45°F).

A representative pedon on a steep, north-facing slope (about 30 percent slope) about 300 m (1,000 ft) north of the southwest corner of Section 23, T10S, R24E follows:

A_{11}	0 cm to 5 cm (0 in. to 2.0 in.)--brown (10YR5/3) channery sandy loam; brown (10YR4/3) when moist; weak, thick, platy structure; soft, very friable, slightly sticky, and non-plastic; many fine roots; moderately calcareous; moderately alkaline (pH 8.0).
A_{12}	5 cm to 12 cm (2.0 in. to 4.7 in.)--brown (10YR5/3 very channery sandy loam; brown (10YR5/3) when moist; massive; soft, friable, slightly sticky, and non-plastic; many fine roots; moderately calcareous; moderately alkaline (pH 8.2).
Cca	12 cm to 25 cm (4.7 in. to 9.8 in.)--pale brown (10YR6/3) very channery sandy loam; brown (10YR5/3) when moist; massive; hard, friable; slightly sticky, and non-plastic; plentiful fine roots; moderately calcareous (pH 8.7).
C_1	25 cm to 35 cm (9.8 in. to 3.8 14 in.)--pale brown (10YR6/3) very channery, very flaggy sandy loam; brown (10YR5/3) when moist; massive; slightly hard, friable, slightly sticky, and non-plastic; few fine roots; moderately calcareous; moderately alkaline (pH 8.9).
R	Sandstone bedrock.

As soils are used for wildlife habitat and for winter sheep grazing. Permeability is moderate and runoff is medium. The hazard of erosion is moderate. This soil will hold about 2.5 cm (1.0 in.) of available water.

AsC-BsE Complex, 10 to 50 percent slopes (As1): This moderately extensive mapping unit occurs entirely in the western part of the survey area and is extensive in the Southam Canyon drainage basin. About 40 to 55 percent of the complex is As channery and sandy loam on 10 to 20 percent slopes (AsC), and 25 to 35 percent is Bs channery loam on 30 to 50 percent slopes (BsE). As channery loam on 10 to 20 percent slopes (AsC) occurs on narrow terrace segments and north-facing slopes. Bs channery sandy loam on 30 to 50 percent slopes (BsE) occurs mainly on steep, south-facing and west-facing ledgy escarpments with narrow outcropping sandstone and very shallow soil between the ledges.

Included within this mapping unit are small areas of Ds channery sandy loam on 5 to 10 percent slopes (DsB); As channery sandy loam on 20 to 40 percent slopes (AsD); and rock outcrop (R), a massive sandstone of the Uinta Formation.

As Channery Sandy Loam, 10 to 20 percent slopes (As2): This mapping unit is of very limited extent. It occurs on a high terrace (elevation about 1,780 m (5,840 ft)) on the eastern edge of the Southam Canyon drainage in Sections 26 and 27, T10S, R24E. About 75 to 85 percent of the area is As channery sandy loam on 10 to 20 percent slopes (AsC). Inclusions consist mainly of small areas of Bs channery and flaggy sandy loam (BsD) at the edges of the terrace and small areas of rock outcrop (R). Vegetation consists of black sage, shadscale, rabbitbrush, and scattered juniper.

AsC-BsC Complex, 10 to 20 percent slopes (AsC-Bs3): This mapping unit is of limited extent and occurs mainly in the northwest part of Southam Canyon area on an upland terrace area in Sections 17 and 20, T10S, R24E. About 45 to 55 percent of the complex is As channery sandy loam on 10 to 20 percent slopes (AsC); about 25 to 35 percent is Bs channery and sandy loam on 10 to 20 percent slopes. Inclusions are mainly Ds channery sandy loam on 5 to 10 percent slopes (DsB) and As channery sandy loam on 5 to 10 percent slopes (AsB).

Because of its limited size, a small area of AsB-BsC complex (5 to 20 percent slopes) is included with this complex. This inclusion differs in that it occurs on more gentle slopes. It is located in the corridor in the northwest portion of the area, mainly in the northwest corner of Section 17 and the northeast corner of Section 18, T10S, R24E.

AsC-BsD Complex, 10 to 20 percent slope (As4): This mapping unit is moderately extensive and occurs mainly in Asphalt Wash drainage in the extreme western portion of the area and in the corridor in the northwestern portion. About 45 to 55 percent of the complex is As channery and sandy loam on 10 to 20 percent slopes (AsC) and about 25 to 35 percent is Bs channery loam on 20 to 40 percent slopes (BsD).

The As channery sandy loam on 10 to 20 percent slopes (AsC) occurs mainly on north-facing and east-facing slopes, and the Bs channery sandy loam on 20 to 40 percent slopes (BsD) generally occurs in the steeper, south-facing and west-facing slopes.

Included with this complex are areas of rock outcrop usually associated with the steeper Bs channery sandy loam (BsD), small areas of Ds channery sandy loam in drainageways, and small areas of As channery sandy loam on 20 to 40 percent slopes (AsD).

AsC-Uinta Sandstone Complex, 10 to 20 percent slopes (As5): This complex is of limited extent and occurs mainly in the northwest quarter of Section 12, T10S, R24E about 1.6 km (1 mi) south of the White River bridge.

About 55 to 65 percent of the complex is As channery sandy loam on 10 to 20 percent slopes and about 15 to 25 percent is rock outcrop (R). Inclusions are mainly Bs channery sandy loam in small drainageways. Vegetation is mainly sagebrush and shadscale.

B Soils: B soils consist of very shallow channery and flaggy loams. The soil depth ranges from about 5 cm to 25 cm (2 in. to 10 in.) and overlies bedrock of the Green River Formation. The soils occur in upland settings on 5 to 40 percent slopes. These soils are generally on south-facing and west-facing slopes. B soils occur in association with A soils. The A soils occur generally on north-facing and east-facing slopes. Elevations range from 1,590 m to 1,710 m (5,200 ft to 5,600 ft). Vegetation consists of sparse growths of shadscale, black sagebrush, Indian ricegrass, curly grass, and annual weeds. The average annual precipitation ranges from about 15 cm to 20 cm (6 in. to 8 in.), and the mean annual soil temperature is 4°C to 7°C (40°F to 45°F).

The following is a representative pedon on a 30 percent south-facing slope with sparse growth of shadscale and black sagebrush, located in the southwest quarter of Section 20, T.10S.R.25E.:

A$_1$	0 cm to 3 cm (0 in. to 1.2 in.)--pale brown (10YR6/3) channery loam; brown (10YR4/3) when moist; weak, thin, platy structure; soft, friable, slightly sticky, and slightly plastic; few fine roots; moderately calcareous; moderately alkaline.
C	3 cm to 20 cm (1.2 in. to 7.9 in.)--pale brown (10YR6/3) very channery loam; brown (10YR4/3) when moist (60 to 70 percent channers and flagstones); slightly hard, friable, slightly sticky, and slightly plastic; few fine and medium roots; moderately calcareous; strongly alkaline.
R	Green River Formation.

B soils are used for wildlife habitat and limited grazing. Permeability is moderate. Runoff is medium, and the hazard of erosion is moderate to severe. This soil will hold only about 1.5 cm to 2.5 cm (0.6 in. to 1.0 in.) of available water.

BC-AB Complex, 5 to 20 percent slopes (B1): This mapping unit occurs only in the northeastern part of the area, north of the White River. About 45 to 55 percent of the complex is B channery loam on 10 to 20 percent slopes; 25 to 30 percent is A channery loam on 5 to 10 percent slopes. Inclusions are B channery loam on 5 to 10 percent slopes, D channery sandy loam on 5 to 10 percent slopes, and the Green River Formation. B soils occur mainly on south-facing slopes and ridge tops; A soils are mainly on north-facing slopes; D soils are in the swales; and the Green River Formation outcrops on ridge tops and south-facing slopes, in close association with B channery loam.

BD-Green River Formation Complex, 20 to 40 percent slopes (B2): This unit occurs in the eastern part of the area on rolling hills between Hells Hole Canyon and Evacuation Creek drainage. About 50 to 60 percent of the complex is B channery loam on 20 to 40 percent slopes. About 20 to 30 percent is the Green River Formation. Inclusions are mainly A channery loam on 10 to 20 percent slopes and D channery sandy loam on 5 to 10 percent slopes in drainage bottoms. BD channery loam occurs on all aspects in this mapping unit. The Green River Formation occurs mainly on ridge tops, knolls, and south-facing hillsides.

Included with this mapping unit is a small area of similar soil on a 5 to 10 percent slope. This area is located in the southeast one quarter of Section 18, T10S, R25E.

BD-AD Complex, 20 to 40 percent slopes (B3): This unit occurs in the southeast portion of the area in Sections 29 and 30, T10S, R25E and in Section 25, T10S, R24E. About 50 to 60 percent of the area is B channery loam on 20 to 40 percent slopes; and about 20 to 25 percent is A channery loam on 20 to 50 percent slopes. Inclusions are mainly rock outcrop of the Green River Formation and D sandy loam on 5 to 10 percent slopes along drainageways.

Bs Soils: Bs soils consist of very shallow channery and flaggy sandy loams. The soil depth ranges from about 5 cm to 25 cm (2 in. to 10 in.) and overlies bedrock of the Uinta Formation. The soils occur in upland settings, with slopes ranging from about 5 to more than 50 percent. B soils occur in association with rock outcrop of the Uinta Formation and with As soils. Bs soils are similar to B soils, but are sandier in texture, and the coarse fragments are sandstone. Elevations range from about 1,620 m to 1,770 m (5,300 ft to 5,800 ft). Vegetation consists of juniper, black sagebrush, shadscale, rabbitbrush, and bluebunch wheatgrass. Average annual precipitation ranges from about 15 cm to 23 cm (6 in. to 9 in.) and the mean annual soil temperature is about 5°C to 7°C (41°F to 45°F).

The following is a description of a representative pedon on a 23 percent west-facing slope with sparse growth of black sage, shadscale, Indian ricegrass, and slender wheatgrass, located in the southwest one quarter of Section 21, T10S, R24E.

A_1 0 cm to 10 cm (0 in. to 3.9 in.)--pale brown (10YR6/3) very channery sandy loam; brown ((10YR4/3) when moist; weak, thin, platy structure; loose, friable, slightly sticky, and slightly plastic; few fine roots; moderately calcareous; moderately alkaline (pH 8.2).

C_1 10 cm to 18 cm (3.9 in. to 7.1 in.)--light yellowish brown (10YR6/4) channery sandy loam; dark yellowish brown (10YR6/4) when moist; massive; loose, friable, slightly sticky, and non-plastic; common fine and medium roots; moderately calcareous; moderately alkaline (pH 8.4).

Cr 18 cm to 23 cm (7.1 in. to 9.1 in.)--shattered flagstones about 1 cm (0.4 in.) thick with thin lime coating on bottom; fine roots between layers of rock.

R Sandstone bedrock.

Bs soils are used for wildlife habitat and limited sheep grazing during winter. Permeability is moderate. Runoff is medium to high, and the hazard of erosion is moderate to severe. This soil will hold about 1.5 cm (0.6 in.) of available water.

BsD-Uinta Sandstone Complex, 20 to 40 percent slopes (Bs1): This mapping unit occurs to a limited extent mainly in the northwestern part of Southam Canyon and in the Asphalt Canyon drainage. About 45 to 55 percent of the complex is Bs channery and flaggy sandy loam on 20 to 40 percent slopes (BsD). About 25 to 35 percent is rock outcrop of the Uinta Formation (R). Inclusions are mainly As channery sandy loam on 20 to 40 percent slopes (AsD) and Ds channery sandy loam on 5 to 10 percent slopes (DsB).

BsE-AsE Complex, 40 to 60 percent slopes (Bs2): This mapping unit is of limited extent. It is located in the corridor in the extreme southern part west of Evacuation Creek. About 50 to 60 percent of the complex is Bs very channery and very flaggy sandy loam located on steep, south-facing slopes. About 25 to 30 percent is As channery sandy loam on 40 to 60 percent slopes and occurs on north-facing slopes. Inclusions are mainly rock outcrop (R) and small areas of Ds channery sandy loam in narrow drainages.

BsE-Uinta Sandstone Complex, 40 to 60 percent slopes (Bs3): This mapping unit is extensive in the western part of the area. About 50 to 60 percent of the complex is Bs very channery and very flaggy sandy loam on 40 to 60 percent slopes. About 30 to 60 percent is rock outcrop of the Uinta Formation. Inclusions are mainly As very channery sandy loam on 20 to 40 percent slopes (AsD).

This complex occurs on all aspects, but is most extensive on south-facing and west-facing escarpments. The vegetation consists mainly of scattered shadscale, rabbitbrush, black sage, and Indian ricegrass.

Bs Channery Sandy Loam, 10 to 20 percent slopes (Bs4):

This mapping unit occurs in the western part of the survey area, mainly in Southam Canyon and in the corridor area in the northwestern portion north of the White River. About 75 to 85 percent of this mapping unit is Bs channery sandy loam on 10 to 20 percent slopes. As soil is closely associated with Bs soil and often occurs as small step-like terraces on the uphill side of individual juniper or sagebrush. Also included in this unit are narrow rims of rock outcrop (R) and small areas of Ds channery sandy loam on 5 to 10 percent slopes (DsB) in small drainages. Included with this mapping unit are some small areas of Bs channery sandy loam on 5 to 10 percent slopes.

BsC-Uinta Sandstone Complex, 10 to 20 percent slopes (Bs5):

This complex occurs in the western upland portion of the Evacuation Creek drainage and is most extensive in the western half of Sections 26 and 35, T10S, R24E, and in the Asphalt Creek drainage in the extreme western part of the area.

About 55 to 60 percent of the complex is As channery sandy loam on 10 to 20 percent slopes (AsC), and about 20 to 30 percent is rock outcrop (R). Inclusions are mainly Bs channery sandy loam on 20 to 40 percent slopes (BsD) and on 5 to 10 percent slopes (BsB). There are also small areas of As channery sandy loam on 10 to 20 percent slopes (AsC) and Ds channery sandy loam (DsB) in narrow drainages. The vegetation is mainly juniper, sagebrush, and shadscale.

Uinta Sandstone-BsE Complex, 40 to 70 percent slopes (R):

This mapping unit is extensive in the central and western parts of the area. About 45 to 55 percent of the complex is massive Uinta sandstone which occurs as ledges and cliffs on very steep slopes. Some of the cliffs extend upward over 30 m (100 ft) from their base to elevations of 1,750 m (5,750 ft). An estimated 30 to 40 percent of the complex is Bs soil (very channery and very flaggy sandy loam) on 40 to 70 percent slopes. The Bs soil usually occurs on small, steep terraces between narrow sandstone ledges. Inclusions consist mainly of small areas of As channery sandy loam on 20 to 40 percent slopes and Bs channery sandy loam on 20 to 40 percent slopes.

Ds Soils: Ds soils consist mainly of sandy loams more than 150 cm (59 in.) deep; however, the total depth to underlying bedrock is not known. The soils are forming in alluvium mainly from Uinta sandstone. The soil occurs in relatively narrow drainages below steep-sloping soils and rock outcrop, and actively-cutting gullies occur in each drainage area. It is most extensive in the Southam Canyon drainage basin but is found in practically all parts of the area. The vegetation is mainly sagebrush with some greasewood, fourwing saltbush, rabbitbrush, and shadscale. The slope range is about 5 to 10 percent.

The average annual precipitation ranges from about 18 cm to 23 cm (7 in. to 9 in.), and the mean annual soil temperature ranges from about 5°C to 7°C (41°F to 45°F).

A representative pedon in a narrow drainageway with a 5 percent slope is located about 370 m (1,200 ft) east of the northwest corner of Section 13, T10S, R24E and is as follows:

A_1 0 cm to 6 cm (0 in. to 2.4 in.)--pale brown (10YR6/3) sandy loam with about 18 percent fine channers; brown (10YR4/3) when moist; weak, thin, platy structure; soft, friable, slightly sticky, and slightly plastic; few very fine roots; moderately calcareous; moderately alkaline (pH 8.0); clear smooth boundary.

C_1 6 cm to 30 cm (2.4 in. to 11.8 in)--light yellowish brown (10YR6/4) channery sandy loam; dark yellowish brown (10YR4/4) when moist; massive; slightly hard, very friable, slightly sticky, and slightly plastic; abundant fine roots; moderately calcareous; moderately alkaline (pH 8.3); gradual smooth boundary.

C_2 30 cm to 137 cm (11.8 in. to 53.9 in.)--light yellowish brown (10YR6/4) channery sandy loam; dark yellowish brown (10YR4/4) when moist; massive; slightly hard; very friable, slightly sticky, and slightly plastic; few fine roots; moderately calcareous; moderately alkaline (pH 8.2).

These soils are used for wildlife habitat and for winter sheep grazing. Permeability is moderate, and runoff is medium. The hazard of erosion is moderate. This soil will hold about 18 cm to 20 cm (7 in. to 8 in.) of available water to a depth of 150 cm (59 in.). Roots penetrate easily.

Ds sandy loam, 5 to 10 percent slopes (D): This is the only unit mapped in the Ds series. It occurs throughout the area but is probably most extensive in the Southam Canyon area. About 75 to 80 percent of the area mapped is Ds sandy loam on 5 to 10 percent slopes (DsB).

Inclusions consist of flaggy sandy loam or channery sandy loam areas, mainly near the heads of drainageways. Small areas with surfaces of loamy sand and channery loamy sand occur mainly in the Southam Canyon drainage. Near the outer edges of some drainages the depth to bedrock varies from 75 cm to 100 cm (30 in. to 40 in.). Included with this mapping unit are a few small areas in the eastern part of the area with loamy texture. In a few locations at the head of drainages the slopes range from 10 to 15 percent.

E Soils: E soils consist of deep, loamy soil. They occur above the present flood plain of the White River, in close association with N soils. Elevations range from about 1,560 m to 1,590 m (5,100 ft to 5,200 ft). Vegetation consists of rabbitbrush, shadscale, cheatgrass, needlegrass, and annual weeds.

Average annual precipitation ranges from about 15 cm to 23 cm (6 in. to 9 in.) and the annual soft temperature is about 5°C to 7°C (41°F to 45°F).

Following is a description of a representative pedon on a stream terrace located about 300 m (1,000 ft) north and 300 m (1,000 ft) west of the center of Section 17, T10S, R24E.

A_1 0 cm to 10 cm (0 in. to 3.9 in.)--brown (10YR5/3) fine sandy loam; brown (10YR4/3) when moist; weak, thin, platy structure; soft, friable, slightly sticky, and slightly plastic; few very fine roots; moderately calcareous; moderately alkaline (pH 8.2).

C_1ca 10 cm to 23 cm (3.9 in. to 9.1 in.)--pale brown (10YR4/3) loam; brown (10YR4/3) when moist; weak, subangular, blocky structure; slightly hard, friable, slightly sticky, and slightly plastic; plentiful fine roots; strongly calcareous; moderately alkaline (pH 8.2).

C_2ca 23 cm to 47 cm (9.1 in. to 18.5 in.)--very pale brown (10YR7/3) loam; yellowish brown (10YR5/4) when moist; moderate, medium, subangular, blocky structure; slightly hard, friable, slightly sticky, and slightly plastic; few fine roots; strongly calcareous; moderately alkaline (pH 8.4).

C_3ca 47 cm to 75 cm (18.5 in. to 29.5 in.)--light yellowish brown (10YR6/4) loam; yellowish brown (10YR5/4) when moist; massive; slightly hard, friable, slightly sticky, and slightly plastic; strongly calcareous; strongly alkaline (pH 8.6).

C_4 75 cm to 150 cm (29.5 in. to 59.1 in.)--light yellowish brown (10YR6/4) fine sandy loam; yellowish brown (10YR5/4) when moist; massive; slightly hard, friable, slightly sticky, and slightly plastic; moderately calcareous; moderately alkaline (pH 8.1).

EB soils are used for wildlife habitat and winter sheep grazing. Permeability is moderate and runoff is low. The hazard of erosion is slight. This soil will hold 20 cm to 25 cm (8 in. to 10 in.) of available water. Roots penetrate easily.

EB-NB Complex, 5 to 10 percent slopes (EN): This mapping unit is of very limited extent and is located mainly on river terraces south of the White River about 15 m (50 ft) above the present flood plain. About 45 to 55 percent is E fine sandy loam on 5 to 10 percent slope (EB), and about 25 to 35 percent is N sandy loam on 5 to 10 percent slopes (NB). There are inclusions of Ds sandy loam on 5 to 10 percent slopes (DsB), a few knolls and bars of quartzite cobble and gravel, and small areas of rock outcrop. E fine sandy loam is deep, medium textured, and well drained. The soil is calcareous throughout and has a moderately strong calcic horizon in the subsoil.

N sandy loam is deep, moderately well drained, moderately fine textured, and calcareous. The subsoil has strong columnar structure and is strongly affected by sodium.

F Soils: The F soils consist of shallow to very shallow sandy soils that range from about 10 cm to 38 cm (4 in. to 15 in.) deep and overlie sandstone bedrock of the Uinta Formation. The soil occurs in upland settings, and slopes range from about 3 to 7 percent. F soils occur in association with rock outcrop (R) and with Bs sandy loam on 10 to 20 percent slopes (BsC). Elevations range from about 1,590 m to 1,610 m (5,200 ft to 5,280 ft). Vegetation is mainly spring hopsage, rabbitbrush, black sagebrush, shadscale, and cheatgrass. Average annual precipitation ranges from about 15 cm to 20 cm (6 in. to 8 in.), and the mean annual soil temperature is about 4°C to 8°C (40°F to 45°F).

Following is a description of a representative pedon on a 3 percent slope on a ridgetop located about 400 m (1,300 ft) north and about 210 m (700 ft) east of the southwest corner of Section 13, T10S, R24E.

A_1	0 cm to 4 cm (0 in. to 1.6 in.)--pale brown (10YR6/3) loamy sand; brown (10YR4/3) when moist; weak, fine, platy structure; soft, very friable, nonsticky, and non-plastic; moderately calcareous; moderately alkaline (pH 8.1); clear smooth boundary.
C_1	4 cm to 17 cm (1.5 in. to 6.5 in.)--pale brown (10YR6/3) loamy sand; dark yellowish brown (10YR4/4) when moist; weak, medium, subangular, blocky structure; soft, very friable, nonsticky, and non-plastic; abundant fine and medium roots; moderately calcareous; moderately alkaline, (pH 8.2); clay smooth boundary.
C_2ca	17 cm to 35 cm (6.7 in. to 13.5 in.)--pale brown (10YR6/3) channery loamy sand; dark yellowish brown (10YR4/3) when moist; massive; soft, very friable, nonsticky, and non-plastic; moderately calcareous; moderately alkaline (pH 8.5); sandstone bedrock at 35 cm (13.8 in.).
R	Sandstone bedrock

F soils are used for wildlife habitat and limited winter sheep grazing. Permeability is moderate to rapid. Runoff is medium to high, and erosion hazard is moderate to severe. This soil will hold about 1.5 cm to 2.5 cm (0.6 in. to 1.0 in.) of available water.

FB-R Complex, 3 to 7 percent slopes (FR): This complex occurs in the western upland portion of the Evacuation Canyon drainage and is of very limited extent. The main area is in the western part of Section 13 and the eastern part of Section 14, T10S, R24E.

About 40 to 50 percent of the complex is F loamy sand on 3 to 7 percent slopes (FB), and about 35 to 40 percent is rock outcrop. Inclusions are mainly Bs sandy loam on

10 to 20 percent slopes (BsC) and Ds sandy loam on 5 to 10 percent slopes (DsB).

F loamy fine sand is a shallow to very shallow sandy soil over sandstone bedrock of the Uinta Formation.

N Soils: N soils consist of deep, moderately fine textured soils that occur mainly on stream terraces. They are most extensive on terraces about 15 m (50 ft) above the present flood plain of the White River. These soils also occur on terraces above the present flood plain of Evacuation Creek. Slopes range from about 5 to 10 percent; however, slopes are mainly about 5 percent. On the White River terraces, N soils are closely associated with E soils, and the mapping units are complexes of these two soils. Along Evacuation Creek the N soils are associated with Ds soils and the mapping unit is a complex of N and Ds soils. Elevations range from about 1,550 m to 1,580 m (5,100 ft to 5,200 ft). Vegetation consists mainly of greasewood, shadscale, hopsage, and annual weeds. The average annual precipitation ranges from about 18 cm to 23 cm (7 in. to 9 in.), and the mean annual soil-temperature ranges from about 5°C to 7°C (41°F to 45°F).

The following is a description of a representative pedon on a stream terrace on the west side of Evacuation Creek, about 152 m (500 ft) east of the south side and center of Section 13, T10S, R24E.

A_2	0 cm to 9 cm (0 in. to 3.5 in.)--pale brown (10YR6/3) fine sandy loam; brown (10YR4/3) when moist; weak, thin, platy structure; soft, friable, slightly sticky, and slightly plastic; few fine roots; moderately calcareous; strongly alkaline (pH 8.7); clear smooth boundary.
B_{21}	9 cm to 20 cm (3.5 in. to 7.9 in.)--reddish brown (5YR3/3) when moist; strong, coarse, prismatic structure; very hard, firm, sticky, and very plastic; few fine roots; thin, nearly continuous clay films; strongly calcareous; strongly alkaline (pH 8.9); clear smooth boundary.
B_{22}	20 cm to 34 cm (7.9 in. to 13.4 in.)--light brown (7.5YR6/4) silty clay loam; brown (7.5YR4/4) when moist; moderate, medium, prismatic, breaking to strong, medium, subangular, blocky structure; hard, firm, sticky, and plastic; moderately calcareous; strongly alkaline (pH 8.5); gradual wavy boundary.

NB-DsB Complex, 5 to 10 percent slopes (ND): This mapping unit occurs mainly along narrow terraces on both sides of Evacuation Creek. About 45 to 55 percent of the complex is N fine sandy loam on 5 to 10 percent slopes (NB), and about 25 to 35 percent is Ds sandy loam on 5 to 10 percent slopes. The NB soil is deep, moderately well drained, and moderately fine textured. The subsoil has strong columnar structure and is strongly affected with alkali. Ds soils are deep, well drained, and moderately coarse textured. Inclusions consist mainly of E fine sandy loam on 5 to 10 percent slopes (EB) and the immediate channel area of Evacuation Creek. There are also small areas of rock outcrop.

W Soils: W soils are deep and imperfectly drained, form in silty alluvium deposited by the White River, and occur adjacent to the present floodplain of the river. The area is about 1/3 km (1/2 mi) wide and extends along the northern corridor of the project area. Vegetation consists mainly of large cottonwood trees, tamarisk, rabbitbrush, and saltgrass. Slopes are generally less than 2 percent. Average annual precipitation ranges from about 18 cm to 23 cm (7 in. to 9 in.), and the mean annual soil temperature ranges from about 5°C to 7°C (41°F to 45°F).

Following is a description of a representative pedon in an area of large cottonwood trees with an understory of saltgrass and rabbitbrush, located in the northwest quarter of Section 17, T10S, R24E.

A_1	0 cm to 10 cm (0 in. to 3.9 in.)--grayish brown (10YR5/2) silt loam; brown (10YR4/3) when moist; thin, medium, platy structure; slightly hard, friable, slightly sticky, and slightly plastic; strongly calcareous; moderately alkaline (pH 8.2).
A_{12}	10 cm to 20 cm (3.9 in. to 7.9 in.)--pale brown (10YR6/3) silt loam; brown (10YR5/3) when moist; massive; slightly hard, friable, slightly sticky, and slightly plastic; strongly calcareous; moderately alkaline (pH 8.2).
C_1	20 cm to 65 cm (7.9 in. to 25.6 in.)--pale brown (10YR6/3) silty clay loam; brown (10YR4/3) when moist; massive; hard, firm, sticky, and plastic; strongly calcareous; moderately alkaline (pH 8.0).
C_2	65 cm to 120 cm (25.6 in. to 47.2 in.)--pale brown (10YR6/3) fine sandy loam; brown (10YR4/3)

C_1ca	34 cm to 55 cm (13.4 in. to 21.7 in.)--light brown (7.5YR6/4) silty clay loam; brown (7.5YR5/4) when moist; massive; hard, firm, sticky, and plastic; strongly calcareous; moderately alkaline (pH 8.2); gradual boundary.
C_2ca	55,6 cm to 89 cm (21.7 in. to 35.0 in.)--light brown (7.5 YR6/4) silty clay loam; brown (7.5YR5/4) when moist; massive; hard, firm, sticky, and plastic; strongly calcareous; moderately alkaline (pH 8.1); gradual boundary.
C_3	89 cm to 158 cm (35 in. to 62 in.)--light brown (7.5YR6/4) heavy loam; brown (7.5YR5/4) when moist; massive; slightly hard, friable, slightly sticky, and slightly plastic; moderately calcareous; moderately alkaline (pH 8.3).

N soils are used for wildlife habitat and winter sheep grazing. Runoff is moderate to rapid. Permeability is low, and the hazard of erosion is moderate. This soil will hold about 15 cm to 20 cm (6 in. to 8 in.) of water to a depth of 150 cm (59 in.).

NB-EB Complex, 5 to 10 percent slope (NE): This mapping unit is limited in extent. It occurs mainly on gently-undulating river terraces on the north and south sides of the White River. These terraces are about 15 m to 23 m (50 ft to 75 ft) above the present river flood plain. The areas are not continuous but occur as small isolated areas, mainly on the north side of the White River. About 45 to 55 percent of the complex is N fine sandy loam on 5 to 10 percent slopes (NB). About 25 to 35 percent is E fine sandy loam on 5 to 10 percent slopes (EB). The NB soil is deep, moderately well drained, and moderately fine textured. The subsoil has strong columnar structure and is strongly affected with sodium. The EB soil is deep, medium textured and well drained. The soil is calcareous throughout and has a moderately strong calcic horizon in the subsoil. Inclusions consist mainly of Ds sandy loam on 5 to 10 percent slopes (DsB) and a few knolls and bars consisting of quartzite cobble and gravel that contain very little fine soil material.

Included with this unit is an area in the southeast quarter of Section 2, T10S, R24E. This area is on the south side of the White River at Ignacio. About 75 to 85 percent of this area is NB soil. Much of it is seriously eroded and much of the original surface soil removed. Inclusions are mainly knolls of quartzite cobble and gravel. Because of its small size, this area was not mapped separately.

when moist; massive; soft, friable, slightly sticky, and slightly plastic; moderately calcareous; moderately alkaline (pH 8.2). Distinct brownish yellow (10YR6/6) mottles below 90 cm (35.4 in.).

C_3 120 to 195 cm (47.2 to 76.8 in)--pale brown (10YR6/2) silt loam; brown (10YR4/3) when moist; massive; slightly hard, friable, slightly sticky, and slightly plastic; strongly calcareous; moderately alkaline (pH 8.1). Distinct brownish-yellow (10YR6/6) mottles.

This soil is used for wildlife habitat and summer cattle grazing. Permeability is moderate and runoff is low. The soil will hold 20 cm to 25 cm (8 in. to 10 in.) of available water.

W silt loam, 0 to 2 percent slopes (W): This is the only unit mapped in the Ws series. About 70 to 80 percent of the area mapped is W silt loam on 0 to 2 percent slopes. Inclusions consist mainly of deep, fine sand, loamy sand, or stratified sandy loam and sand. The sandier inclusions are mainly along more recent bars and beaches of the White River. Vegetation is mainly a young growth of tamarisk, willows, and rabbitbrush. Also included in the unit is the present stream channel of the river.

b. Soil Formation

The characteristics of a soil at any given point are determined by the interaction of five principal soil factors: (1) parent material; (2) climate; (3) topography, relief; (4) biota, e.g., plants, animals and man; and (5) time.

The soils along the flood plain of the White River and along smaller drainageways throughout the area have formed in alluvium. The alluvium along the White River has come from a wide range of transported materials, whereas in the smaller drainages the materials are largely deep sandy loams and channery sandy loams from the local Uinta and Green River formations. The parent material for the upland soils that comprise a large portion of the area is mainly the Uinta Formation and the Green River Formation. The soils are mainly shallow or very shallow overlying these formations.

Two important climatic factors in the formation of soils on the tracts are precipitation and temperature. There are no data for this specific area, but data are available for Vernal, Utah, where the average yearly precipitation is about 20 cm (8 in.), and the average precipitation is about 1.5 cm (0.6 in.) per month from October through March and from June through July, and about 2.0 cm (0.8 in.) per month during April, May, September, and October. On the tracts the average annual soil temperature at a 51 cm (20 in) depth is estimated to be slightly less than 8°C (47°F), which places the soils in the frigid soil family.

The tracts are in the Colorado Plateau physiographic province. The province is distinguished by the approximate horizontality of the bedrock and the numerous canyons and generally high elevation. Most of the area is between 1,520 m and 1,830 m (5,000 ft and 6,000 ft) above sea level. The topography of the area is sloping to steep slopes ranging from about 5 percent to over 60 percent. The western part of the survey area is characterized by numerous nearly vertical sandstone cliffs. The eastern part of the area, east of Evacuation Creek has more rolling topography and fewer sandstone cliffs.

Vegetation influences soil formation mainly through the addition of organic matter from leaves, stems, and roots. Shrubs, forbs, and grasses are the dominant vegetation over much of the area. Juniper trees are common at higher elevations, above 1,650 m (5,400 ft) west of Evacuation Creek, with scattered pinyon pine at the highest elevations. An open stand of large cottonwood trees occurs along the White River valley. Young willows and tamarisk occur in the most recent deposits. Big sagebrush is the dominant vegetation along numerous drainageways throughout the area. Shadscale, black sage, cheatgrass, Indian ricegrass, squirreltail, and some forbs are common on shallow upland soils. Greasewood and shadscale are common in alkali-affected areas. Burrowing animals are important in mixing the various soil materials, and the mounds and disturbed areas are conspicuous in the survey area. Grazing animals also affect soils by removing vegetation, which tends to increase erosion. Man has affected soil development in the area by building roads and trails, which contribute to erosion.

Time is essential in soil formation, whether a few years or centuries. Entisols, for instance, such as the Typic Torrifluvents, along the drainageways, are young soils that have not been in place and undisturbed long enough for distinct horizons to develop. Typic Natrargids are examples of soils with well-differentiated horizons. These soils occur on higher terraces, which implies greater age, or more time for soil-forming processes to act.

c. Soil Classification

The nine different soil types found on the tracts are classified on Table V-1. Table V-1 shows the two soil orders of Entisols and Aridisols. Soil orders are soils with similar sets of soil-forming processes. Entisols are soils that lack distinct horizons and Aridisols are generally dry and have light-colored or thin surface horizons with well-expressed lime horizons (calcic horizon) or sodic horizons (natic horizon).

Soil orders are divided into suborders, primarily on the basis of closest genetic similarity. The suborders in the survey area, identified by the last two syllables of the subgroup, are orthids, orthents, fluvents, and argids. The basis for this division is differences resulting from climate or vegetation, or the presence or absence of waterlogging.

The great group is a subdivision of the suborder. An example of a great group name is Calciorthid, which are aridisols with a strong calcic horizon. Great groups are based on the uniformity in the kinds and sequence of major soil horizons and properties. The horizons used to make separations are those in which clay, iron, humus, or lime have accumulated, or those that have layers that interfere with root growth or the movement of water. Properties used also include soil temperature and major differences in chemical composition.

Great groups are divided into subgroups. There is a central (typic) concept of the group, and intergrades that have slightly different properties. Lithic Calciorthid is a subgroup that indicates a shallow soil less than 51 cm (20 in.) to bedrock with a strong calcic horizon.

Families are based on the properties important to the growth of plants or to engineering. Among the properties considered are texture, mineralogy, reaction, and soil temperature. Coarse-loamy, for example, indicates a sandy-loam texture; mixed indicates the clay mineralogy is varied. Frigid indicates that the mean annual soil temperature 51 cm (20 in.) deep is less than 8°C (47°F). Soils with mean annual temperatures below 47°F are considered too cold for most farm crops to mature.

TABLE V-1

SOILS CLASSIFICATION

Soil	Family	Subgroup	Order
A	Loamy-skeletal, mixed, frigid	Lithic Calciorthid	Ardisols
As	Loamy-skeletal, mixed, frigid	Lithic Calciorthid	Aridisols
B	Loamy-skeletal, mixed (calcareous) frigid	Lithic Torriorthent	Entisol
Bs	Loam-skeletal, mixed (calcareous) frigid	Lithic Torriorthent	Entisol
Ds	Coarse-loamy, mixed (calcareous) frigid	Typic Torrifluvent	Entisol
E	Coarse-loamy, mixed, frigid	Typic Calciorthid	Aridisol
F	Coarse-loamy, mixed (calcareous) frigid	Lithic Torriorthent	Entisol
N	Fine, mixed frigid	Typic Natrargid	Aridisol
W	Fine, mixed (calcareous) frigid	Aquic Ustifluvent	Entisol

The soils were not classified into soil series because of the limited size of the survey area.

d. Laboratory Analysis of Soils

Soils were sampled by horizon from selected locations and analyzed by the USU Cooperative Soils Laboratory (U. S. Dept. of Agriculture, 1967). The soils were analyzed for physical and chemical properties important to characterizing and classifying the soils. The laboratory data sheets are presented in Appendix V-1. Table V-2 gives selected data for the different soils, including soil type, depth sampled, particle size distribution; textural class; reaction, or pH; organic carbon; electrical conductivity; calcium carbonate equivalent percent; extractable cations (Mg, Na and K); available P; and percentage of moisture at saturation.

The following is an explanation of the soil-sample analyses shown in Table V-2. The textural class varies from silty loams, sandy loams, clay loams, and loams. The pH of the samples vary from about 7.8 to 8.9, not especially high for soil high in calcium carbonate. Extractable sodium is moderate except in Soil N which shows 11 to 20 milliequivalents of Na per 100 g of soil. In other upland soils the extractable sodium is highly variable, and occasionally increases in horizons near bedrock.

The organic carbon content of the surface soils varies from 0.5 percent to 2.6 percent, and generally decreases with depth, which is typical for soils in this setting. The exception is soil W, which has 5 percent organic carbon in the surface layer.

Electrical conductivity, or salinity, is generally low, especially in the upper 40 cm (16 in.). The exception is soil N with electrical conductivity values ranging from less than 3 mmhos/cm at 20 cm (8 in.) to 33 mmhos/cm at 34 cm (13 in.) depth. Soil W conductivity varies from less than 2 mmhos/cm in the surface to 28 mmhos/cm at 130 cm (51 in.).

The calcium carbonate equivalent varies from about 3 percent to 30 percent in surface layers and 5 percent to 50 percent in the subsoils. The values are typical for soil formed from calcareous rocks in areas with less than 15 cm to 23 cm (6 in. to 9 in.) of annual precipitation.

The values of extractable cations are typical for a soil formed from saline calcareous sandstone with these climatic conditions.

TABLE V-2

LABORATORY ANALYSIS OF SELECTED SOILS

Soil Name & Collec. No.	Depth From Surface (cm)	Size Class and Diameter of Particles														Extract. Cations NH$_4$OAc Me/100g.				
		Very Coarse Sand 2-1 mm	Coarse Sand (1-0.5 mm)	Medium Sand (0.5-.25mm)	Fine Sand (0.25-.10mm)	Very Fine Sand (0.10-0.05mm)	Silt (0.05-.002 mm)	Clay <0.002 mm	% Sand	% >2mm	Text-ural Class	pH Satur. Paste	Organ. Carbon	Elect/ Conduct mmhos/cm	CaCo^3 Equiv. %	Mg	Na	K	Avail. P ppm	% Moist. Satur.
A #68	0-8	7	4	4	15	18	38	14	48	28	L	8.1	1.5	.5	2.9	1.0	.5	.4	7.5	32
	8-20	10	6	4	13	12	40	20	40	55	L	8.1	1.4	.6	8.4	1.1	1.1	.2	2.0	47
	20-33	22	11	5	8	7	35	17	48	44	L	8.6	1.0	.8	9.8	.6	4.6	.1	1.1	44
	33-50	17	10	6	13	10	26	17	47	77	L	8.7	0.9	1.2	5.3	.6	10.4	.2	2.8	48
As #67	0-5	10	9	12	19	9	27	14	59	39	SL	8.0	1.4	.5	7.0	.4	.4	.3	6.9	38
	5-12	13	8	8	20	15	28	15	58	60	SL	8.2	1.5	.6	8.6	1.0	1.3	.1	1.6	52
	12-25	14	9	7	16	12	34	14	52	67	SL	8.7	1.2	1.0	10.7	1.6	7.2	.1	1.1	51
	25-35	18	12	8	20	11	32	13	65	63	SL	8.9	0.6	1.8	7.9	1.6	8.4	.1	.8	40
B & Bs #63	0-8	9	8	7	17	11	38	20	42	44	L	8.0	.5	.7	7.2	1.5	.9	.2	4.9	28
	8-14	7	4	3	7	8	55	21	24	40	Sil	7.5	.7	1.7	11.4	3.3	5.8	.2	2.1	42
	14-27	6	3	1	5	11	60	25	15	52	Sil	8.3	.5	2.5	14.2	3.5	10.9	.2	.5	44
Ds #64	0-10	9	9	11	21	11	27	11	62	13	SL	8.1	1.1	.6	5.8	1.1	.3	.3	17.0	32
	10-40	14	14	14	23	8	19	11	70	24	SL	8.1	.5	.4	5.9	.9	.5	.1	3.6	30
	40-65	12	14	13	20	9	23	12	65	20	SL	8.1	.4	.6	9.2	.5	.8	.1	3.7	31
	65-113	11	16	15	21	9	21	11	68	15	SL	8.1	.4	2.6	7.5	.9	3.8	.1	4.1	33
	113-150	12	12	13	22	11	23	10	67	21	SL	8.1	.3	28.0	7.2	.5	12.9	.2	2.4	29
E #76	0-10	2	2	3	15	32	31	8	61	2	SL	8.2	.6	.5	5.2	1.5	.3	.5	7.9	31
	10-23	1	1	2	9	23	41	16	43	1	L	8.2	.5	.7	12.5	2.6	.6	.2	1.3	33
	23-47	1	1	1	6	24	45	23	32	0	L	8.4	.4	.7	18.7	3.3	1.7	.2	.8	37
	47-75	3	3	6	20	17	33	19	48	3	L	8.6	.3	.9	11.9	2.4	3.5	.2	.7	31
	75-120	4	6	8	22	14	29	14	57	14	SL	8.1	.4	4.2	9.4	1.7	5.2	.1	1.0	34
	120-150	8	8	9	22	13	25	14	61	26	SL	8.0	.4	18.0	7.8	1.7	10.1	.2	1.4	30
F #39	0-4	2	11	30	29	8	9	8	83	4	LS	8.1	.5	.6	3.0	1.0	.3	.4	16.0	29
	4-17	6	13	30	25	6	11	11	78	7	SL	8.2	.5	.5	3.7	1.3	.5	.2	3.2	32
	17-35	11	19	27	21	5	8	10	72	25	LS	8.5	.5	.3	6.8	1.0	.5	<.1	1.0	38
N #48	0-9	1	1	3	16	33	33	10	37	1	SL	8.7	.3	.9	4.5	2.4	1.7	.9	6.4	28
	9-20	<1	1	2	12	26	34	27	39	1	L	8.9	.3	2.4	10.5	3.9	11.4	.3	3.4	48
	20-34	<1	1	2	8	15	35	38	27	0	CL	8.5	.3	14.0	15.2	5.7	19.8	.2	1.8	62
	34-55	<1	1	3	12	16	35	31	34	1	CL	8.2	.2	33.0	15.5	5.7	19.6	.2	1.0	48
	55-89	<1	1	2	7	21	40	30	30	0	CL	8.1	.2	22.0	15.4	5.0	15.7	.1	1.0	48
	89-158	1	2	2	8	17	46	26	28	2	L	8.3	.1	20.0	11.7	5.0	13.5	.2	.6	49
W #75	0-10	7	1	1	1	2	62	23	15	0	Sil	8.2	5.1	1.4	11.3	5.5	1.3	2.7	27.0	67
	10-20	<1	1	1	5	9	60	17	34	0	Sil	8.2	1.1	1.5	11.0	4.0	1.6	1.7	2.1	47
	20-30	1	1	<1	1	2	59	38	4	0	SiCL	8.0	1.2	14.0	12.0	8.9	7.8	1.5	2.0	65
	30-65	<1	<1	<1	1	2	64	34	3	0	SiCL	8.1	1.0	24.0	11.4	11.5	13.3	.7	2.0	60
	65-90	<1	<1	1	40	31	17	8	75	0	SL	8.2	.3	16.0	6.0	4.5	4.6	.2	1.2	33
	90-130	<1	<1	<1	29	37	23	8	69	0	SL	8.3	.5	16.0	7.1	5.8	5.7	.1	.7	34
	130-195	1	1	<1	2	4	68	17	15	0	SiL	8.1	.8	28.0	12.3	10.0	13.3	.3	.7	51

The available phosphorus is highly variable but is concentrated in the surface soil and decreases markedly with increasing depth. The percentage of moisture at saturation is the percentage by weight of water the soil can hold. The moisture-holding capacity depends on texture, organic matter, structure, and other factors.

The results of X-ray analysis of 15 soil samples are shown in Table V-3. The type of clay minerals present are determined by this method. Clay mineralogy is the basis for classifying the soil at the family level. Boron at selected depths of five soils, shown in Table V-4, ranges from 0.2 ppm to 1.4 ppm.

According to Richards (1954):

> Permissible limits for boron in the saturation extract of soils can at present be given only on a tentative basis. Concentrations below 0.7 ppm boron probably are safe for sensitive plants; from 0.7 to 1.5 ppm boron is marginal; and more than 1.5 ppm boron appears to be unsafe. The more tolerant plants can withstand higher concentrations, but limits cannot be set on the basis of present information.

e. Use and Management of Soils

The area is managed by BLM. It is used mainly as winter range for sheep; however, some cattle use the bottomlands along the White River for summer range. Mule deer are the principal game species that use the range.

Table V-5 gives the estimated herbage yields for favorable and unfavorable years and capability classes for the nine soils. The capability classes indicate the suitability of the soils for most kinds of crops. The classes are designated I through VIII. (The numerals indicate progressively greater limitations and narrower choices for practical use.) The nine soils in the area were placed in two capability classes, VI and VII. Class VI soils have severe limitations that generally make them unsuited to cultivation and limit their use largely to pasture or range, woodland or wildlife. Class VII soils have very severe limitations that make them unsuited to cultivation and restrict their use largely to range, woodland, or wildlife.

The "e" shows that the main limitation is the risk of erosion; the "w" indicates that the soil is wet.

TABLE V-3

RESULTS OF X-RAY ANALYSIS OF 15 SOIL SAMPLES FROM OIL SHALE TRACTS U-a AND U-b

Soil	Sample #	Depth (cm)	Quartz	Calcite	Dolomite	Feldspar	Illite	Kaolinite	Montmorilloni
D_s	22	25-36	X	X	?	X	X-1	X-1	
A	37	8-22	X	X		?	X-5	X-5	X-1
A	38	27-53	X	X		X	X-5		X-1
A	39	17-35	X	X		X		X-5	X-1
B_s	40	31-137	X	X		X		X-5	X-1
B_s	42	41-60	X	X	X		?	?	X-1
E	45	40-76	X	X					X-1
E	46	20-45	X	X		X	X-4	X-5	X-1
A	48	55-89	X	X		X	X-2	X-3	X-1
A	50	11-30	X	X		X			X-1
A_s	53	23-45	X	X					X-1
A_s	54	17-30	X	X				X-5	X-1
D_s	55	40-120	X	X			X-1	X-1	?
D_s	58	34-72	X	X		X	X-5	X-5	X-1
D_s	63	14-27	X	X	?	X	X-5	X-5	X-1

X means the mineral appears in the less than 2μ fraction. The clay minerals are ranked in order of abundance, with 1 being most abundant and 5 least abundant. Abundances are only estimates.

TABLE V-4

RESULTS OF THE BORON TESTS ON SOIL SAMPLES FROM TRACTS U-a AND U-b

Soil	Pedon #	Depth (cm)	Boron (ppm)
Ds	#64	10-40	0.3
	#63	113-150	0.4
W	#75	30-65	0.4
	#75	130-195	0.2
E	#76	120-150	0.5
Ds	#45	40-76	1.4
	#45	76-121	0.9
N	#48	20-34	1.3
	#48	34-55	1.0

TABLE V-5

ESTIMATED HERBAGE* YIELDS IN KG/HA AND LAND USE CAPABILITY CLASSES OF SOILS

Soil	Yields Favorable yrs. Kg/ha	Yields Unfavorable yrs. Kg/ha	Capability Classes
A	800	400	VIe
B	400	200	VIIe
As	1000	600	VIIe
Bs	450	250	VIIe
D	1250	900	VIe
E	1250	900	VIe
F	400	200	VIIe
N	150	100	VIIe
W	3500	2000	VIw

*Total yield of above-ground plant parts

Conversion from kg/ha to lb./ac is made by multiplying kg/ha values by 0.9.

The high erosion potential in the area is closely related to the topography. Seventeen mapping units out of a total of 26 have slopes of over 10 percent. Six units have slopes ranging from 5 percent to 10 percent. Two mapping units have slopes of 3 percent to 8 percent. Only one unit has slopes less than 2 percent.

f. Engineering Uses of the Soils

For any engineering use, it is important to consider certain physical characteristics of a soil, including permeability, strength, compaction characteristics, drainage, shrink-swell potential, grain size, plasticity, and reaction. Also important are slope, depth to bedrock and depth to water table.

Table V-6 (U. S. Dept. of Agriculture, 1971) gives the estimated and measured properties of soils on the site, including slope, depth to bedrock, texture class, Unified System and AASHO classification, liquid limit, plastic limit, permeability, available water capacity, pH, electrical conductivity, shrink swell potential, and hydrologic soil group.

The two systems used most frequently in classifying soils for engineering are the Unified System used by the SCS, the U. S. Bureau of Reclamation, the Department of Defense, and the U. S. Corps of Engineers, and the AASHO system adopted by the American Association of State Highway Officials (Am. Assoc. of St. Hwy Officials, 1955). In the Unified System, soils are classified according to particle-size distribution, plasticity, liquid limit, and organic matter. Soils are grouped into 15 classes. There are eight classes of coarse-grained soils, identified as GW, GP, GM, GC, SW, SP, SM, and SC; and six classes of fine-grained soils, identified as ML, CL, OL, MH, CH, OH, and PT. Soils on the borderline between the two classes are designated by symbols for both classes, for example ML-CL.

The AASHO system is used to classify soils according to properties affecting highway construction and maintenance. In this system soils are placed in one of seven basic groups, ranging from A-1 through A-7, on the basis of grain-size distribution, liquid limit, and plasticity index. Group A-1 comprises gravelly soils of high bearing strength. At the other extreme is group A-7, comprising clay soils that have low strength when wet and are the poorest for subgrade. Where laboratory data are available to justify a further breakdown, group A-1, A-2 and A-7 may be divided into subgroups, such as A-2-4.

TABLE V-6

ESTIMATED AND MEASURED SOIL PROPERTIES SIGNIFICANT TO ENGINEERING REQUIREMENTS

Soil	Slope Range (%)	Depth to Bedrock (cm)	Texture Class	Unified	AASHO	Liquid Limit	Plastic Limit	Permeability (In/Hr)	In/In Available Water Capacity	pH	ECe mmhos/cm	Shrink-Swell Potential	Hydrologic Soil Groups
A	3 to 40	30 to 50	channery loam	SM GC	A-2-4	24-33	NP-0	1.0-2.5	0.09-0.11	7.5-8.7	0.4-5.4	Low	C (moderately high runoff potential)
As	5 to 60	30 to 50	channery sandy loams	SM GM	A-2-4	24-36	NP	1.5-3.0	*0.1	8.1-8.5	0.3-6.0	Low	C (moderately high runoff potential)
**B	5 to 40	5 to 25	channery loams	SM GM	A-2-4	20-30	NP	1.0-2.5	*0.1	7.5-8.2	0.7-3.0	Low	D (high runoff potential)
**Bs	10 to 60	5 to 25	channery sandy loams	SM GM	A-2-4	20-30	NP	1.5-3.0	*0.1	7.5-8.3	0.7-2.5	Low	D (high runoff potential)
Ds	5 to 10	150+	sandy loam to channery sandy loam	SM	A-2-4	20-23	NP	1.0-2.4	0.12-0.14	7.9-8.3	1.0-19.0	Low	B (moderately low runoff potential)
E	5 to 10	150+	fine sandy loams to loams	ML CL SM	A-4 A-6	20-27	NP-8	1.0-2.5	0.14-0.16	7.7-8.6	0.4-18.0	Low	B (moderately low runoff potential)
**F	3 to 7	10 to 40	loamy sands	SM	A-2	20-30	NP	2.0-4.0	*0.1	8.1-8.5	0.3-0.6	Low	D (high runoff potential)
**N	5 to 10	150+	fine sandy loam surface silty clay loam subsoil	CL	A-4 or A-6	20-30	5-15	0.05-0.20	0.14-0.16	8.1-8.9	5.0-15.0	Moderate	D (high runoff potential)
W	0 to 2	150+	silt loams to silty clay loams - some sands	CL SM	A-4 A-6	20-47	2-16	0.20-1.50	0.16-0.18	8.0-8.3	1.5-28.0	Moderate	B (moderately low runoff potential)

* less than
** estimate

Hydrologic soils groups are used in watershed planning to estimate runoff from rainfall. The soil properties considered are those influencing the minimum rate of infiltration of a bare soil after prolonged wetting. These properties are depth of seasonally high water table, intake rate and permeability after prolonged wetting, and depth to very slowly permeable layers. The influence of ground cover is considered independently.

Soils with a low runoff potential have high, or rapid, infiltration rates even when thoroughly wetted, and consist mostly of deep, well to excessively drained sands or gravels. They also have a high rate of water transmission.

Soils with a moderately low runoff potential have moderate infiltration rates when thoroughly wetted and consist mainly of moderately deep to deep, moderately well drained to well drained soils with moderately fine to moderately coarse textures and moderately slow to moderately rapid permeability. They also have a moderate rate of water transmission.

Soils with a moderately high runoff potential have slow infiltration rates when thoroughly wetted and consist mainly of soils with a layer that impedes downward movement of water, soils with moderately fine to fine texture, soils with slow infiltration due to salts or alkali, or soils with moderate water tables. They may be somewhat poorly drained. There are also well drained and moderately well drained soils that have slowly permeable and very slowly permeable layers (hardpans, hard bedrock) at moderate depths 50 cm to 100 cm (20 in. to 39 in.).

Soils with a high runoff potential have very slow infiltration rates when thoroughly wetted and consist mainly of clay soils with a high swelling potential; soils with a permanent high water table; soils with a claypan or clay layer at or near the surface; soils with very slow infiltration due to salts or alkali; and shallow soils over nearly impervious material. They also have a very slow rate of water transmission.

In Table V-6, the estimates of permeability are for soils in place and are based on the structure, texture, and porosity of the soil material and on field observations. The available water capacity, given in inches per inch of soil, is the capacity of the soil to hold water available for most plants. It is commonly defined as the difference between the amount of water in the soil at field capacity and the amount at wilting point.

The shrink-swell potential is an indication of the volume change to be expected of the soil material with changes in moisture content. In general, soils with a high shrink-swell potential are hazardous if used in building materials or as a foundation.

The reaction is the intensity of acidity or alkalinity of a soil, expressed in pH values. A pH of 7.0 is neutral; a lower value indicates acidity and a higher value indicates alkalinity. The pH values range from about 7.8 to 8.9. Since these values are not especially high for soils high in calcium carbonate, the corrosiveness of the soil solution would not seriously damage pipelines. Salinity affects the suitability of the soil for plants, its stability when used as construction material, and its corrosiveness to other materials.

Table V-7 gives the interpreted engineering properties of soils, including ratings of soils as a source of topsoil, sand, gravel, roadfill, sanitary landfill cover materials, and cover of spent shale deposits; and rating of their limitations as foundations for low buildings, septic tank filter fields, sewage lagoons, and shallow excavations. Soil features affecting their use as pond-reservoir areas or for embankments to hold water are also shown. Interpretations are based on test data and field experience with soils in the area and similar soils in other areas. It should be emphasized that the interpretations made in this survey are not a substitute for on-site sampling and testing needed at a site chosen for specific engineering work that involves heavy loads, or a site where excavations are deeper than the depths of the layers here reported.

The soils were rated on the degree and kind of limitation affecting their use as septic tank absorption fields, sewage lagoons, sanitary landfill, dwellings with and without basements, and local roads and streets. The ratings are as follows:

> "Slight" means that the soil has a few limitations that are easily overcome.
>
> "Moderate" means that the soil has limitations that can generally be overcome by proper planning, careful design, and good management.
>
> "Severe" means that the soil limitations are severe enough to make the use of the soil questionable. Engineering designs to overcome the limitations are difficult and expensive.

TABLE V-7

INTERPRETATIONS OF ENGINEERING PROPERTIES OF SOILS

	Degree and Kind of Limitation for							Suitability as a Source of						Soil Features Affecting	
Soil	Septic Tank Absorption Fields	Sewage Lagoons	Sanitary Landfill		Shallow Excavations	Dwellings w/without Basements	Local Roads & Streets	Roadfill	Sand	Gravel	Topsoil	Sanitary Landfill Cover Materials	Cover for Spent Shale Deposits	Pond Reservoir Areas	Dikes, Levees and Other Embankments
			Trench type	Area type											
A	Severe-slope depth	Severe-slope depth	Severe-depth slope	Severe-depth slope	Severe-depth slope	Severe-depth slope	Severe-depth slope	Good to fair A-2-4	Unsuited loam	Poor loam shallow	Poor channery & flaggy	Poor shallow	Poor shallow	shallow, slope	shallow, stones
As	Severe-slope depth	Severe-slope depth	Severe-depth slope	Severe-depth slope	Severe-depth slope	Severe-depth slope	Severe-depth slope	Good to fair A-2-4	Unsuited sandy loam	Poor sandy loam shallow	Poor very channery and flaggy	Poor shallow	Poor shallow	shallow, slope	shallow, stones
B	Severe-slope depth	Severe-slope depth	Severe-depth slope	Severe-depth slope	Severe-depth slope	Severe-depth slope	Severe-depth slope	Good to fair A-2-4	Unsuited loam	Poor loam shallow	Poor very channery and flaggy	Poor very shallow	Poor very shallow	shallow, slope	very shallow, stones
Bs	Severe-slope depth	Severe-slope depth	Severe-depth slope	Severe-depth slope	Severe-depth slope	Severe-depth slope	Severe-depth slope	Good to fair A-2-4	Unsuited sandy loam	Poor sandy loam shallow	Poor very channery and flaggy	Poor very shallow	Poor very shallow	shallow, slope	very shallow, stones
Ds	Slight-5 to 10% slopes	Moderate-5 to 10% slope	Slight	Slight	Slight	Slight	Slight	Good to fair A-2-4	Unsuited sandy loam	Unsuited	Fair Channer Content increases with depth	Fair to good	Fair to good	moderate to slow permeability	medium to high susceptibility to piping, medium shear strength
E	Slight-5 to 10% slope	Moderate-5 to 10% slope	Slight	Slight	Slight	Slight	Slight to moderate A-6 material in subsoil	Fair A-4 A-6	Unsuited sandy loam and loam	Unsuited	Fair to 20 cm strong Ca horizon below	Fair to good	Fair to good	moderate to slow permeability	medium to high susceptibility to piping, medium to low shear strength
F	Severe-depth	Severe-depth	Severe-depth	Severe-depth	Severe-depth	Severe-depth	Severe-depth	Fair A-4	Poor shallow loamy sand	Unsuited	Poor shallow loamy sand	Poor shallow loamy sand	Poor shallow	shallow, rapid permeability	shallow, medium to high susceptibility to piping
N	Severe-moderately slow permeability	Severe-moderately slow permeability	Moderate-moderately slow permeability	Moderate-moderately slow permeability	Slight	Moderate-moderate shrink-swell	Moderate-moderate shrink-swell	Fair to poor A-4 A-6	Unsuited silty clay loam	Unsuited	Poor alkali salts	Poor alkali salts	Poor alkali salts	slow permeability, deep	medium to low shear strength
W	Severe-seasonal high water table Flood danger	Severe-seasonal high water table. Flood danger	Severe-seasonal high water table. Flood danger	Severe-seasonal high water table. Flood danger	Moderate-seasonal high water table. Flood danger	Severe-flood danger. Season high water table.	Severe-flood danger Season high water table.	Fair to poor A-4 A-6	Poor silt loam Inclusive of fine sand	Unsuited	Good silt loam poor fine sand	Good	Fair high salt content in subsoil	high water table	low to high susceptibility to piping, medium to low shear strength

The A, As, B, Bs, and F soils all have severe limitations, mainly because of steep slopes and shallow to very shallow soil mantles over bedrock. The Ds and E soils have slight limitations for most uses but have moderate limitations for sewage lagoons because of the 5 percent to 10 percent slopes. Because of the moderately slow permeability, N soils have severe limitations for septic tank drainage fields and sewage lagoons; the limitations for other uses are mainly moderate. The W soils mainly have severe limitations because of seasonal high water table and flood danger.

Soils were rated for their suitability as a source of roadfill, sand, gravel, topsoil, sanitary landfill cover material, and spent-shale cover material.

The suitability was rated in terms of "good," "fair," and "poor," which parallel the limitation terms "slight," "moderate," and "severe." Most of the soils have a good to fair rating for roadfill material, based on AASHO test data. The exceptions are the N and W soils, which have fair to poor ratings. The soils were rated poor for sand or gravel.

The soils were rated poor for topsoil and as cover for sanitary landfill and spent-shale deposits if they were high in coarse fragments (channers and flaggs), shallow or very shallow to bedrock, and if they were moderately fine textured and contained alkali and salts. It should be noted that the soluble salt content increases markedly in the deeper subsoils; the upper 50 cm to 80 cm (20 in. to 31 in.) is usually best suited as a source of topsoil. The A, As, B, Bs, F, and N soils were rated poor, and the Ds, E, and W were rated fair to good. The D and W soils are the best material for these uses, especially as cover for spent shale. The Southam Canyon area, where the spent shale will likely be deposited, contains about 259 ha (640 acres) of D soils. The W soils along the White River Valley contain some salt and would require transporting some distance to the spent shale site. The suitable E soils would be good for all these uses, but they would be difficult to separate from the unsuitable N soils.

The soil features that affect their use are shown on Table V-7. Depth, slope, permeability, and water table affect their use in pond-reservoir areas. Depth, stoney material, susceptibility to piping, and shear strength affect their use for dams, levees, and other embankment materials. The N and E soils occur in complex in the mapping units on the river terraces above the present flood plain of the White River. The moderately fine textured N soil is a possible source of material for dam construction. The thickness of the material is about 76 cm (30 in.).

The deep soils on the tracts and the 1.6 km (1-mi) perimeter total 1,660 ha (4,100 acres), or approximately 15 percent of the area. The deep soils are D, 850 ha (2,100 acres); NE, 120 ha (300 acres); EN, 110 ha (270 acres) and W, 460 ha (1,140 acres).

g. Soil Infiltration

The soil infiltration study was conducted to generate baseline data for evaluating how the soils will be impacted by land-use changes. These data will also be used with the soils map to estimate runoff volumes by applying the U. S. Soil Conservation Service runoff calculations.

A Rocky Mountain infiltrometer was used to generate runoff from 96 small, movable 76 cm by 30 cm plots (0.23 sq m of soil surface coverage). The soils of most limited extent were not tested. Plots were installed by driving the edges 9 cm (3.5 in) into the soil surface with a specially constructed hammer. An adjustable canvas wind shield was used to prevent wind disturbance and raindrop drift. Plots were pre-wet to field capacity (called "wet plots") prior to an infiltrometer run. Artificial rainfall was applied to the plots at rates of 10 cm to 15 cm (4 in. to 6 in.) per hr for 28 min. Rainfall and runoff rates were determined at 5-min intervals, and infiltration was the difference between these two measurements. Sediment-yield values were also obtained. All samples were taken during October 1974 and October 1975. Sample points are shown on Figure V-2.

Several limitations of these data must be considered. The principal limitation is the difficulty in simulating natural conditions with a small infiltration-test device and the few sites tested. Also, seasonal variations in soil infiltration rates were not tested. The data provided is best used to compare soil types.

Infiltration rates for wet soils are shown in Table V-8. Upland soils have rates of about 3.6 cm (1.4 in.) per hr. The soils of the bottomlands (D soils) have greater rates--about 6.1 cm (2.4 in.) per hour. The soils formed on the alluvium of the White River (W soils) have much slower rates of uptake--about 1.5 cm (0.6 in.) per hr. As expected, soils affected by excess sodium (N soils) have the lowest infiltration rates of all the soils tested--about 0.8 cm (0.3 in.) per hr.

Infiltration rates did not decrease significantly during the 28-min period of the test; in fact, most runs showed no time trend. Runs that did decrease with time had small magnitudes, approximately 1.3 cm (0.5 in.) per hr, and were only apparent for the first 5 min of the run. In addition, soil type was apparently more significant than slope angle in determining infiltration rates. For these reasons, infiltration data can be best summarized as a mean infiltration rate in each soil type.

The rate of application was high to simulate severe storms. Because infiltration rates tend to be lowest in the fall and because the applied rates were high, runoff values should be maximum.

Curve-number means and sediment-yield rates are also shown in Table V-8. The curve numbers can be used to calculate runoff using the SCS method. Since the rates are highly variable, the standard deviations are large. The estimates of sediment yield are used primarily to compare soils.

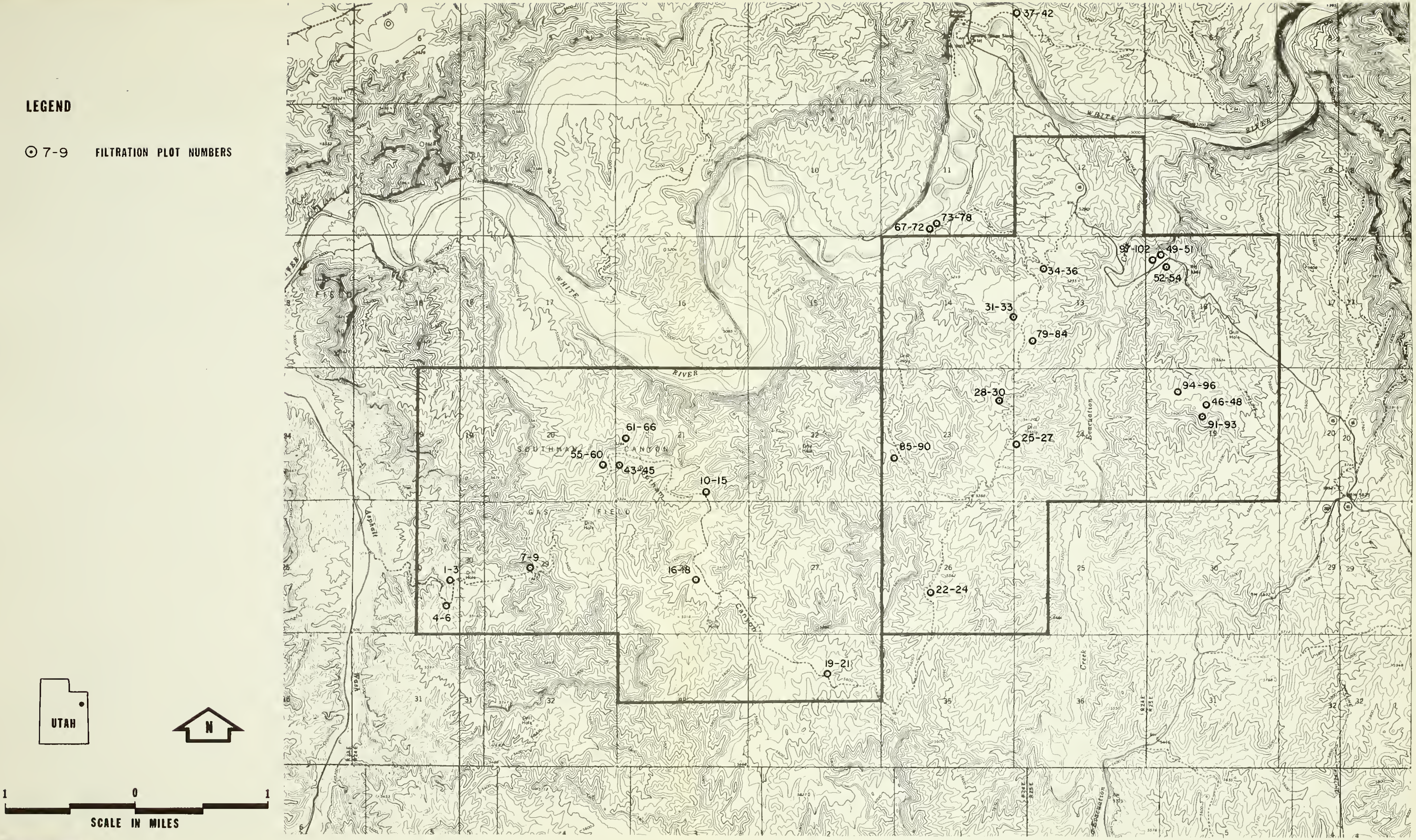
A few sites were not wetted before testing. These dry sites provided some information on the infiltration rates of soils with little antecedent moisture. The infiltration rates of dry soils were a fraction of an inch per hour slower than those of wet soils on the same plots.

Infiltration rates, curve numbers, and sediment yields for all 96 plots are contained in Appendix V-2.

h. Soil Radioactivity

The soils were measured to establish baseline levels of radioactivity in the area and to separate the sources from (1) radioactivities originating from nuclides within the oil shale (usually from nuclides in a uranium decay chain, which could affect the environment); (2) naturally occurring background activity; and (3) radioactivity identified with the worldwide fallout from weapons testing. The radiation levels in tract soils are primarily associated with naturally occurring background activity.

A number of soil samples were collected from representative locations on the two lease tracts and analyzed for radioactivity. No sources above a normal background level were identified, with Ra^{226} activity below 0.87 pCi/g, Sr^{90} below 0.52 pCi/g; K^{40} below 20.0 pCi/g, Pb^{212} below 1.5 pCi/g, Cs^{137} below 1.6 pCi/g recorded for all samples. Detailed results of the soil radioactivity tests are contained in Appendix V-3.



LOCATIONS OF SOIL INFILTRATION PLOTS

FIGURE V-2

TABLE V-8

SUMMARY OF SOIL INFILTRATION RATES

	Mean Infiltration (in./hr)	±1 Std. Dev.	Mean Curve Number	±1 Std. Dev.	Mean Sediment Yield (tons/acre)	±1 Std. Dev.
D_s (wet)	2.4	0.75	86	9.80	0.3	0.25
B_s (wet)	1.5	0.70	92	3.03	0.6	1.02
A (wet)	1.3	0.41	94	2.15	0.2	0.31
A_s (wet)	1.0	0.58	96	1.64	0.1	0.07
W (wet)	0.6	0.46	97	1.51	0.1	0.05
N (wet)	0.3	0.29	98	1.22	0.2	0.13
F (wet)	1.9	0.46	89	4.36	0.1	0.01
E (wet)	1.8	0.75	90	5.08	0.1	0.03
B (wet)	0.5	0.39	96	1.73	0.1	0.05
D_s (dry)	2.4	0.74	89	6.49	0.2	0.09
B_s (dry)	2.8	0.51	86	0.57	0.5	0.23

SOURCE: VTN

To convert from tons/acre to kilograms/hectare multiply by 2242.

i. Relationship Between Soils and Vegetation

Plant available moisture is the most important factor in determining the distribution of vegetation types in the arid west. Soil characteristics are one of the important factors that determine plant available moisture. As a result, distribution of vegetation types often correspond to the distribution of soil types. At the site, where vegetation pattern and soil type distribution coincide, it is usually a function of soil moisture.

Greasewood vegetation occurs exclusively on the D soils at the site. D soils are the deep, sandy loam soils forming in alluvium. They occur in the relatively narrow drainages below steeply sloping soils and rock outcrops. The soil has a relatively high water holding capacity. The correlation between areas of D soil and areas of greasewood vegetation is the closest of any of the soil-vegetation relationships at the site.

Riparian vegetation, as the name implies, is only found in areas adjacent to water and on moist soils. The soils of the site that are moist enough to sustain this type of vegetation are W soils and D soils. The W soils are deep, imperfectly drained, and form in silty alluvium adjacent to the flood plain of the White River. All of the W soil mapped at the site support riparian vegetation. Riparian vegetation also occurs along Evacuation Creek where D soils are moist enough.

The upland soils at the site are similar to one another, but support a variety of vegetation types. The juniper are found at the higher elevations on the thin sandy soils; As, Bs, and F. These are shallow and very shallow sands, sandy loams or loams. The eastern limits of juniper roughly coincide with the limits of these soils along the west side of Evacuation Creek. However, the same soils extend beyond the limits of the juniper because the juniper are limited by their altitudinal requirements. The thin sandy soils that are below the juniper limits to the north and to the west are dominated by big sagebrush.

The soils that have formed on the Green River Formation are the A and B soils, which are very shallow loam soils. These soils are less sandy than the upland soils found on the Uinta Formation. The vegetation on these soils is exclusively the shadscale-black sagebrush type. The shadscale-blacksage type is not limited to soils A and B, however, but also dominates on the sandy soils (As, Bs and F) that occur north of the White River.

4. CONCLUSIONS

The soils of Tracts U-a and U-b are mainly shallow to very shallow (less than 50 cm (20 in.) deep) soils on sloping to steep upland surfaces cut by numerous intermittent drainages and containing many areas of rock outcrop and rock escarpments.

Soils A, As, B, Bs, and F are included in these shallow sites. They consist of sandy loam, loams, channery sandy loams, and channery loams. The coarse-fragment content (channers and flaggs) usually increases with depth, and numerous flagstones with a small proportion of soil occurs immediately above the bedrock. Surface soils are light colored and moderately calcareous. The $CaCO_3$ (lime) content usually increases with depth and occurs as a coating on the undersides of rock fragments.

There are numerous drainageways throughout the tracts. Most of them have intermittent stream channels, and the soils--usually Ds soils--along these channels are generally deep (more than 150 cm (59 in.)), mainly sandy loams or channery sandy loams, light colored, and moderately calcareous. They are the most extensive in the Southam Canyon drainage area.

Along the Evacuation Creek drainage the Ds soils are associated with N soils. The N soils are deep and moderately fine textured and are strongly alkaline with a high concentration of exchangeable sodium. The N soils also occur on stream terraces about 15 m to 30 m (50 ft to 100 ft) above the White River flood plain. In these areas the N soils occur with E soils, which are deep and moderately coarse textured, with a strong $CaCO_3$ (lime) horizon in the subsoil.

The W soils occur adjacent to the White River, mainly in the corridor outside the tracts. They are deep and silty and seasonally wet in the deeper horizons. They generally have a high salt content.

Infiltration rates vary with the soil type. The upland soils (A, As, B, Bs, F) have rates of about 3.6 cm (1.4 in.) per hr. The soils bottomlands (D) have greater rates--about 6.1 cm (2.4 in.) per hr. The soils formed on the alluvium of the White River (W soils) have much slower rates of uptake--about 1.5 cm (0.6 in.) per hr. As expected, soils affected by excess sodium (N soils) have the lowest infiltration rates of all the soils tested--about 0.8 cm (0.3 in.) per hr.

The soils were measured for radioactivity. No sources above a normal background level were identified.

5. WORK SCHEDULED

The soils survey program is complete. Potentially deleterious elements in the soils will be determined.

B. GEOLOGY

1. OBJECTIVES

This report is a compilation of geologic data, interpretations, and conclusions prepared for the White River Shale Project. Included are data necessary to determine the suitability of locations for surface mine facilities, mine-waste and spent-shale disposal areas, and water impoundments, and to establish a baseline for monitoring possible mining-related effects on the environment.

2. METHODOLOGY

Geologic data were gathered in response to the Federal Oil Shale Lease Stipulations, the Partial Exploration Plan, the Geologic Exploration Program Supplement, and the Conditions of Approval of the plan and supplement.

The data are regional and site specific. Site data covers the 41.4 sq km (16 sq mi) of Oil Shale Tracts U-a and U-b as well as land within 1.6 km (1 mi) of the tract boundaries. Regional data covers, in part, the Southeast Uinta Basin; and, in part, the Uinta Basin.

Topics included in this report are physiography, geologic history, stratigraphy, structure, hazards, mineral resources, aquifers, and the oil shale mining zone. The physiography section includes information about landforms, geomorphic processes, slope, elevation, stream characteristics, and climate. The stratigraphic section includes regional and site specific descriptions of Eocene and Quaternary strata. Significant aquifers within the strata are identified. Regional and site specific strikes and dips of strata, folds, faults, and joint patterns are included within the description of structural geology. Possible hazards discussed include earthquakes, landslides, rockfall, and subsidence. Mineral resources within the region which are described are oil shale, oil, natural gas, gilsonite, bituminous sandstone, coal, uranium, gypsum, nahcolite, and alumina. Analyses to determine the grades of oil shale, nahcolite and extractable alumina within the mining zone are included. In addition, the depth, extent, and stratigraphic position of the mining zone, and trace element concentrations within the zone are given.

VTN geologists first reviewed literature pertaining to the geology of the Uinta Basin and to the site. Data from the tract nomination boreholes (HE and HS holes) were then interpreted and used as a basis for selecting sites for further subsurface investigations.

Stratigraphic sections of the Uinta Formation and the Parachute Creek Member of the Green River Formation were measured and described in surface investigations conducted in the vicinity of the tracts during the summer and fall of 1974. During field traverses, bedding and joint orientations were mapped extensively, and the extent of surface exposures of rock formations and quaternary unconsolidated deposits were checked.

Three types of holes were drilled, logged, and cored in selected intervals on and near the tracts to provide adequate subsurface stratigraphic, hyrogeologic, and mineralogic data (Figure V-3). Four pilot test holes (P-holes) were drilled by Fugro Inc. and supervised by VTN between October and November 1974; three of these holes were developed as aquifer pump-test sites. In addition, 29 ground water investigation holes (G-holes) were completed between September and November 1974. Between December 1974 and January 1975, Cleveland Cliffs Iron Company (CCIC) supervised and VTN coordinated the drilling and logging of nine geologic exploration holes (X-holes).

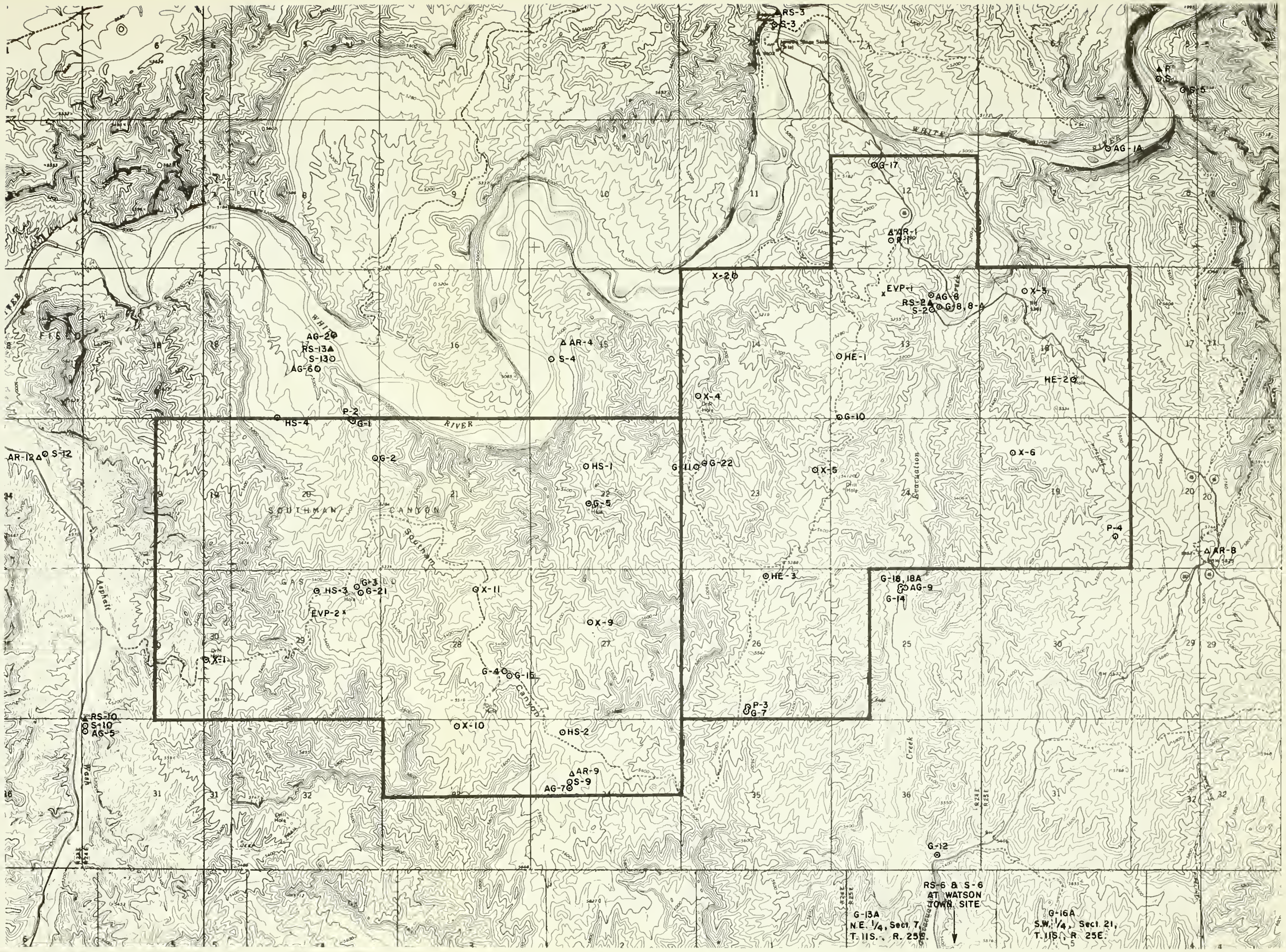
The HE-HS (nomination holes), P-holes, and X-hole locations were selected for maximum spatial distribution of subsurface data. The G-holes were drilled where they would provide the best spatial distribution of ground water information from significant aquifers. All drill-holes were established for minimum surface disturbance. Table V-9 summarizes the types of data collected from the P-holes, X-holes, and G-holes. Hydrogeologic logs of each of these holes were submitted to the WRSP; an example of one of these logs is given in Figure V-4.

VTN engineers conducted a precise re-leveling survey of a series of U. S. Coast and Geodetic Survey first-order benchmarks in the vicinity of the tracts. This survey provided information regarding the amount of subsidence or uplift in the area within the last 42 years.

3. SUMMARY OF RESULTS

a. Physiography

Tracts U-a and U-b are in the southeastern portion of the Uinta Basin, a broad, asymetric basin at the northeastern edge of the Colorado Plateau (Figure V-5). The surface area of the basin is about 18,130 sq km (7,000 sq mi) and corresponds



LEGEND

⊙ S	SURFACE WATER MONITORING STATION
⊙ P	PILOT TEST HOLE (WATER)
⊙ G	GROUND WATER MONITORING STATION
⊙ HE	EXISTING GEOLOGIC CORE HOLE, EVACUATION
⊙ HS	EXISTING GEOLOGIC CORE HOLE, SOUTHAM
⊙ X	EXPLORATION GEOLOGIC CORE HOLE
⊙ AG	ALLUVIAL WELL (WATER)
△ AR	PRECIPITATION, AUTO (WATER)
▲ RS	PRECIPITATION, STORAGE (WATER)
× EVP	EVAPORATION PAN (WATER)

N

1 0 1

SCALE IN MILES

WATER AND GEOLOGIC RESOURCES BASELINE MONITORING STATIONS

FIGURE V-3

TABLE V-9

DATA COLLECTED FROM THE P, X, AND G- HOLES

	P-Holes (4)	X-Holes (9)	G-Holes (29)
Cored Interval	entire hole below surface casing	from approximately 130' above to 120' below the Mahogany marker bed (a key bed lying 3-9 meters above the richest mahogoney beds)	none
Geologic Log	entire hole	generally from entire hole	entire hole
Geophysical Logs			
natural gamma	yes	yes	yes
gamma gamma	yes	no	yes
neutron gamma	yes	no	yes
neutron	no	yes	no
neutron neutron	yes	no	yes
spontaneous potential	yes	yes	yes
fluid resistivity	yes	yes	yes
resistivity (64" normal)	yes	yes	no
lateral electric	yes	no	no
caliper	yes	yes	yes
spinner	yes	yes	yes
fluid temperature	yes	yes	yes
density	no	yes	no
three-dimensional velocity	no	yes	no
Water Conditions			
flow	yes	yes	yes
conductivity	yes	yes	yes
temperature	no	yes	no
static level	yes	yes	yes
Aquifer Tests			
packer	yes	X-3, X-11 only	yes
slug	yes	no	no
pump	yes	no	no

TABLE V-9 (Cont.)

	P-Holes (4)	X-Holes (9)	G-Holes (29)
Fisher Assays	yes	yes	no
Rock Mechanics Tests	yes	yes	no
Chemical Analyses			
extractable alumina	yes	yes	no
nahcolite	yes	yes	no
boron	yes	yes	no
mercury	yes	yes	no
cadmum	yes	yes	no
flouride	yes	yes	no
antimony	yes	yes	no
arsenic	yes	yes	no
selenium	yes	yes	no
molybdenum	no	yes	no

BOREHOLE NO. P-1 (CORE) **TOTAL DEPTH: 377 METERS (1238')**
GROUND SURFACE ELEVATION: 1611 METERS (5284')
LOCATION COORDINATES: N600,465 E2,654,871
DATE COMPLETED 10/11/74

OTHER INFORMATION AVAILABLE FROM THIS BOREHOLE

1. NUCLEAR LOGS { GAMMA GAMMA / NEUTRON GAMMA / NEUTRON NEUTRON
2. FLUID TEMPERATURE LOG
3. BOREHOLE FLOW LOG (SPINNER)
4. ELECTRIC LOGS { FLUID RESISTIVITY / 64'' NORMAL / LATERAL

LEGEND

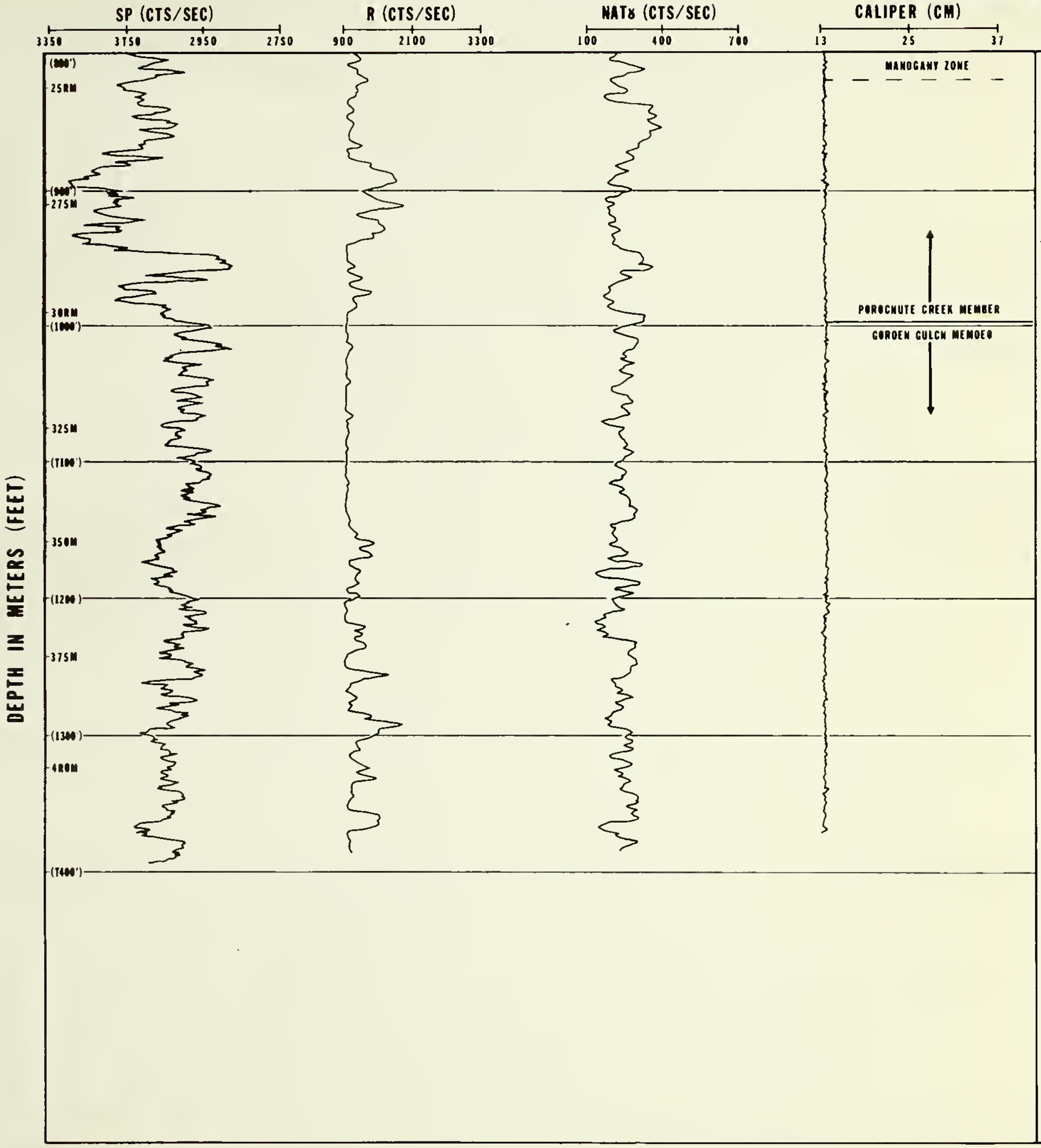
▨ GROUT SEAL
▩ GRAVEL PACK
▦ PERFORATED PIPE

SP = SPONTANEOUS POTENTIAL
R = RESISTIVITY (16'' NORMAL)
NATɣ = NATURAL GAMMA RAY

C = SPECIFIC CONDUCTANCE
K = COEFFICENT OF PERMEABILITY
T = COEFFICENT OF TRANSMISSIBILITY
▽ = STATIC WATER LEVEL

CASING DIAMETER = 9 CM (3 1/2'') O.D.
HOLE DIAMETER = 17 CM (6 3/4'') I.D.

BOREHOLE GEOPHYSICAL LOGS



GEOLOGIC AND LITHOLOGIC DESCRIPTION

off H_2S gas at 245m, 247m-248m. Oil shale at 241m-242m, 248m-250m; high oil content at 236m-237m and 239m-240m

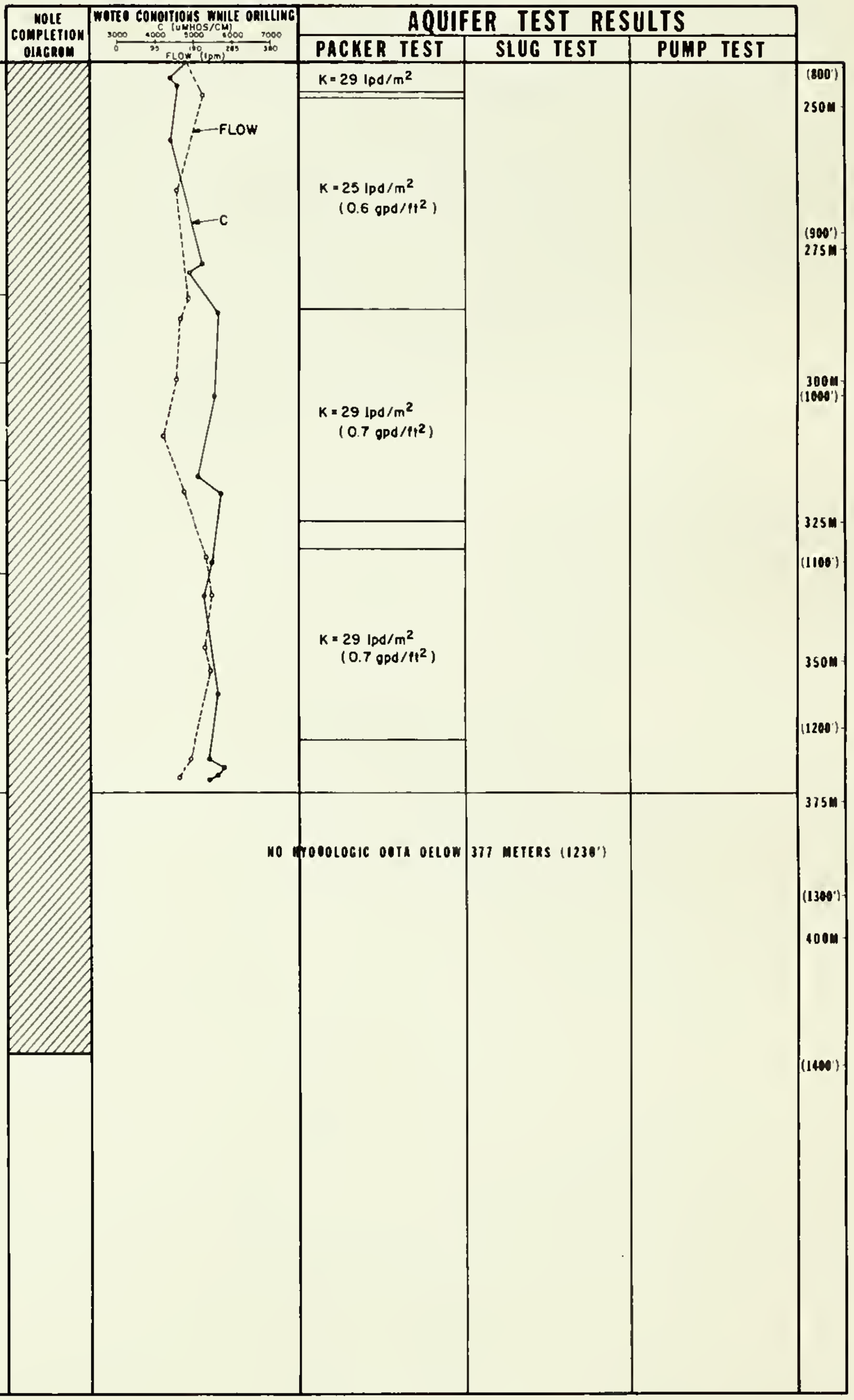
Claystone and siltstone, pinkish gray to dark-red, non-calcareous. Oil shale at 287m-289m, 294m, 296m-297m.

Claystone and marlstone, calcareous, H_2S gas from interbedded silt beds, some pyrite and mica, tuffareous sandstone beds. Oil shale at 296m-298m, 300m-301m, 303m and 312m.

Siltstone and marlstone, light gray to brown gray, non-calcareous to slightly calcareous with shales at 325m-330m, disseminated pyrite at 326m-330m; oil shale at 329m.

Claystone, siltstone and sandstone, massive to thinly bedded, disseminated pyrite from 329m-364m; oil shale at 365m-366m.

NO LITHOLOGIC LOG BELOW 377 METERS (1230')



AQUIFER TEST RESULTS

PACKER TEST	SLUG TEST	PUMP TEST
K = 29 lpd/m^2		
K = 25 lpd/m^2 (0.6 gpd/ft^2)		
K = 29 lpd/m^2 (0.7 gpd/ft^2)		
K = 29 lpd/m^2 (0.7 gpd/ft^2)		

NO HYDROLOGIC DATA BELOW 377 METERS (1238')

HYDROGEOLOGIC INFORMATION, BOREHOLE NO. P - 1 (CONT.)

FIGURE V-4

BOREHOLE NO. P-1 (CORE) TOTAL DEPTH: 377 METERS (1238′)
GROUND SURFACE ELEVATION: 1611 METERS (5284′)
LOCATION COORDINATES: N600,465 E2,654,871
DATE COMPLETED: 10/11/74

OTHER INFORMATION AVAILABLE FROM THIS BOREHOLE

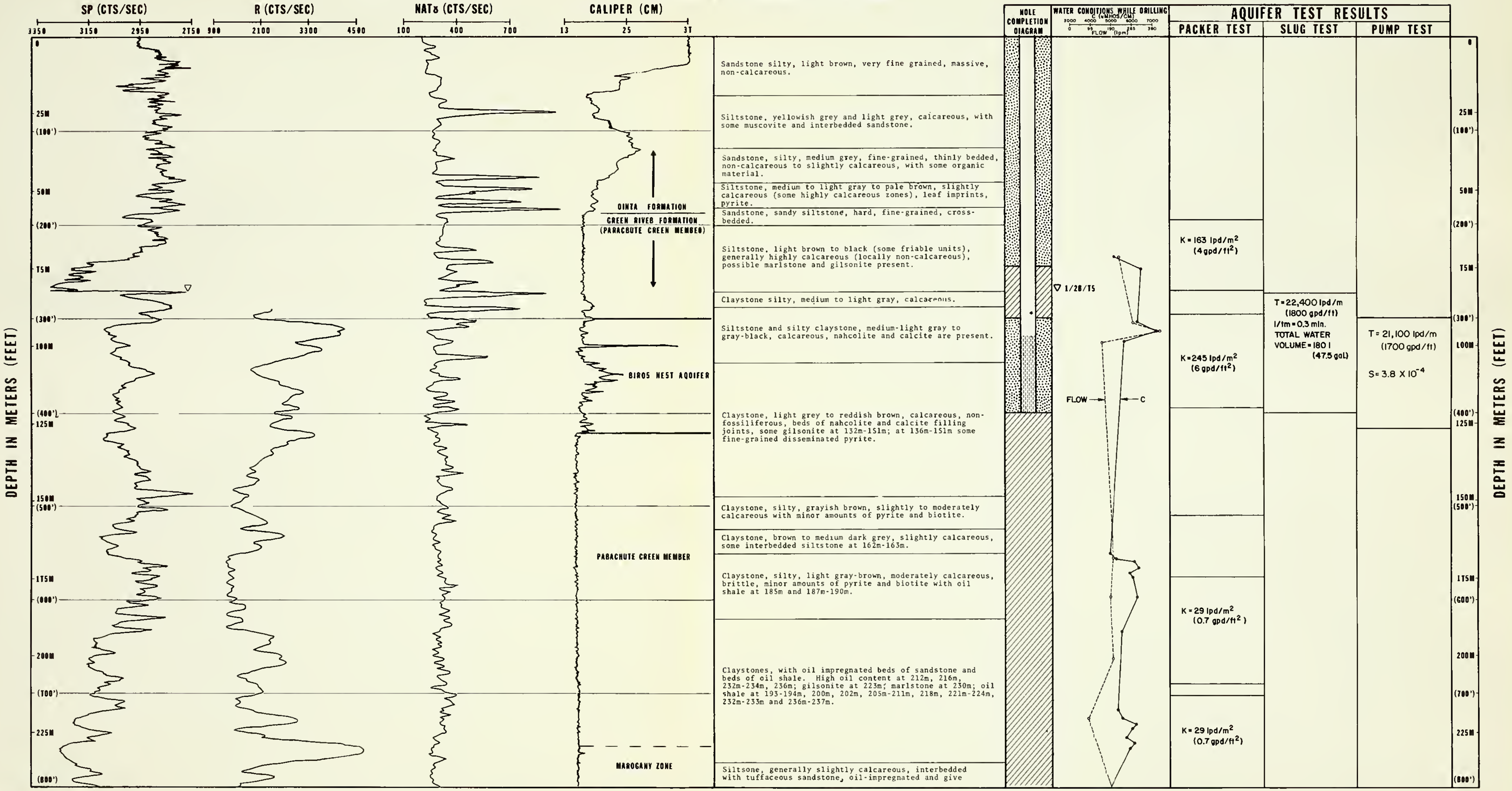
1. NUCLEAR LOGS: GAMMA GAMMA; NEUTRON GAMMA; NEUTRON NEUTRON
2. FLUID TEMPERATURE LOG
3. BOREHOLE FLOW LOG (SPINNER)
4. ELECTRIC LOGS: FLUID RESISTIVITY; 64″ NORMAL; LATERAL

LEGEND

▨	GROUT SEAL
░	GRAVEL PACK
▦	PERFORATED PIPE

SP = SPONTANEOUS POTENTIAL
R = RESISTIVITY (16″ NORMAL)
NATγ = NATURAL GAMMA RAY
CASING DIAMETER = 9 CM (3 1/2″) O.D.

C = SPECIFIC CONDUCTANCE
K = COEFFICENT OF PERMEABILITY
T = COEFFICENT OF TRANSMISSIBILITY
▽ = STATIC WATER LEVEL
S = STORAGE COEFFICIENT
HOLE DIAMETER = 17 CM (6 3/4″) I.D.



GEOLOGIC AND LITHOLOGIC DESCRIPTION

Sandstone silty, light brown, very fine grained, massive, non-calcareous.

Siltstone, yellowish grey and light grey, calcareous, with some muscovite and interbedded sandstone.

Sandstone, silty, medium grey, fine-grained, thinly bedded, non-calcareous to slightly calcareous, with some organic material.

Siltstone, medium to light gray to pale brown, slightly calcareous (some highly calcareous zones), leaf imprints, pyrite.

Sandstone, sandy siltstone, hard, fine-grained, cross-bedded.

Siltstone, light brown to black (some friable units), generally highly calcareous (locally non-calcareous), possible marlstone and gilsonite present.

Claystone silty, medium to light gray, calcareous.

Siltstone and silty claystone, medium-light gray to gray-black, calcareous, nahcolite and calcite are present.

Claystone, light grey to reddish brown, calcareous, non-fossiliferous, beds of nahcolite and calcite filling joints, some gilsonite at 132m-151m; at 136m-151m some fine-grained disseminated pyrite.

Claystone, silty, grayish brown, slightly to moderately calcareous with minor amounts of pyrite and biotite.

Claystone, brown to medium dark grey, slightly calcareous, some interbedded siltstone at 162m-163m.

Claystone, silty, light gray-brown, moderately calcareous, brittle, minor amounts of pyrite and biotite with oil shale at 185m and 187m-190m.

Claystones, with oil impregnated beds of sandstone and beds of oil shale. High oil content at 212m, 216m, 232m-234m, 236m; gilsonite at 223m; marlstone at 230m; oil shale at 193-194m, 200m, 202m, 205m-211m, 218m, 221m-224m, 232m-233m and 236m-237m.

Siltsone, generally slightly calcareous, interbedded with tuffaceous sandstone, oil-impregnated and give

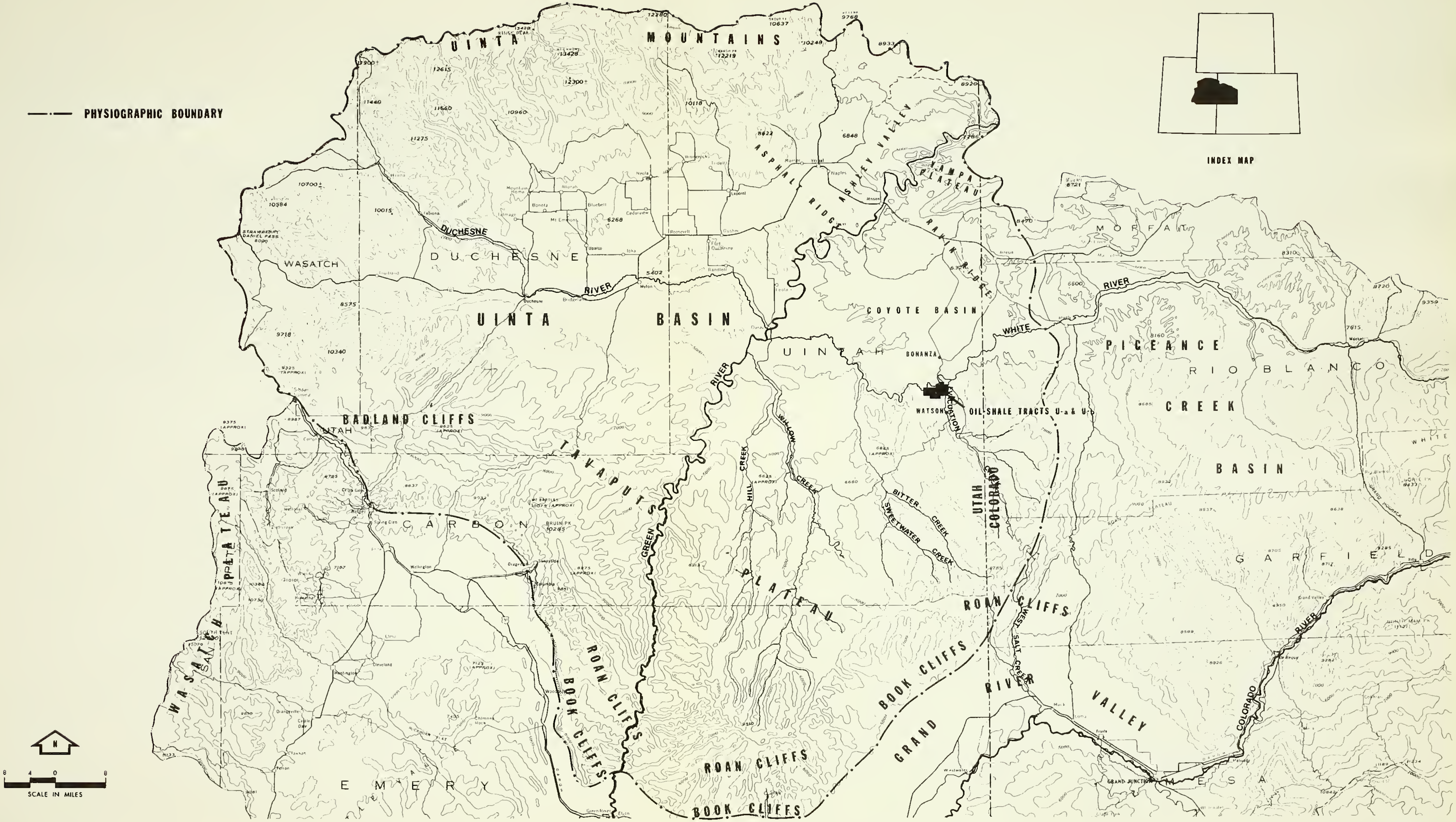
AQUIFER TEST RESULTS

PACKER TEST	SLUG TEST	PUMP TEST
K = 163 lpd/m^2 (4 gpd/ft^2)		
	T = 22,400 lpd/m (1800 gpd/ft) l/tm = 0.3 min. TOTAL WATER VOLUME = 180 l (47.5 gal)	T = 21,100 lpd/m (1700 gpd/ft) S = 3.8 X 10^{-4}
K = 245 lpd/m^2 (6 gpd/ft^2)		
K = 29 lpd/m^2 (0.7 gpd/ft^2)		
K = 29 lpd/m^2 (0.7 gpd/ft^2)		

vtn

HYDROGEOLOGIC INFORMATION, BOREHOLE NO. **P - 1**

FIGURE V-4



PHYSIOGRAPHIC MAP OF THE UINTA BASIN REGION

FIGURE V-5

with a prehistoric depositional lake basin. The maximum dimensions are approximately 209 km (130 mi) along the east-west axis and 161 km (100 mi) along the north-south axis.

The Uinta Basin is also a subsurface structural basin because of the underground geologic structures forming its boundaries (Figure V-6). Major features bordering the basin are the Uinta Mountains to the north, the Wasatch Range to the west, the Roan cliffs to the south, and the highlands associated with the subsurface Douglas Creek Arch along the eastern edge.

The land surface elevation of the center of the basin floor ranges from 1,220 m to 1,524 m (4,000 ft to 5,000 ft); outward from the center the land surface gradually slopes upward to the north, south, and west, reaching 2,896 m to 3,353 m (9,500 ft to 11,000 ft) along the limits of the basin. Although there is no distinct topographic boundary to the east, elevations between 1,829 m and 2,438 m (6,000 ft to 8,000 ft) above the Douglas Creek Arch establish basin limits just east of the Colorado-Utah border.

Tracts U-a and U-b are bounded by the White River to the north, Hells Hole Canyon to the east, upland areas of elevations between 1,829 m and 1,890 m (6,000 ft and 6,200 ft) to the south, and Asphalt Wash to the west.

The region near the tracts, including all the area extending southward to the Roan Cliffs and westward to the Green River, is a gently north sloping, highly dissected plateau characterized by steep-walled canyons with ephemeral streams or dry washes. The relief of these canyons averages several tens of meters and in some places as much as 305 m (1,000 ft).

The elevations on Tracts U-a and U-b range from 1,500 m to 1,890 m (4,920 ft to 6,200 ft) for a maximum relief of 390 m (1,280 ft), as seen on Figure V-7. In general, the lands within Tracts U-a and U-b slope north toward the east-west trending channel of the White River.

The climate within the central portion of the basin is semi-arid, with extremely hot, dry summers and occasional high-intensity thunderstorms. The winters are cold and dry with little snow occurring in the basin itself but heavy snows occurring on the encircling mountains. In his model of morphogenetic regions, L. C. Peltier suggests that these conditions will promote strong chemical weathering, wind erosion, and pluvial erosion; weak to minimum mass movement; and slight or insignificant frost action (Dury, 1969). A land use practice that contributes to erosion is the grazing of sheep and cattle which results in extensive soil trampling, especially on terrace lands along the White River; as a result, the soil there is susceptible to raindrop and sheet erosion.

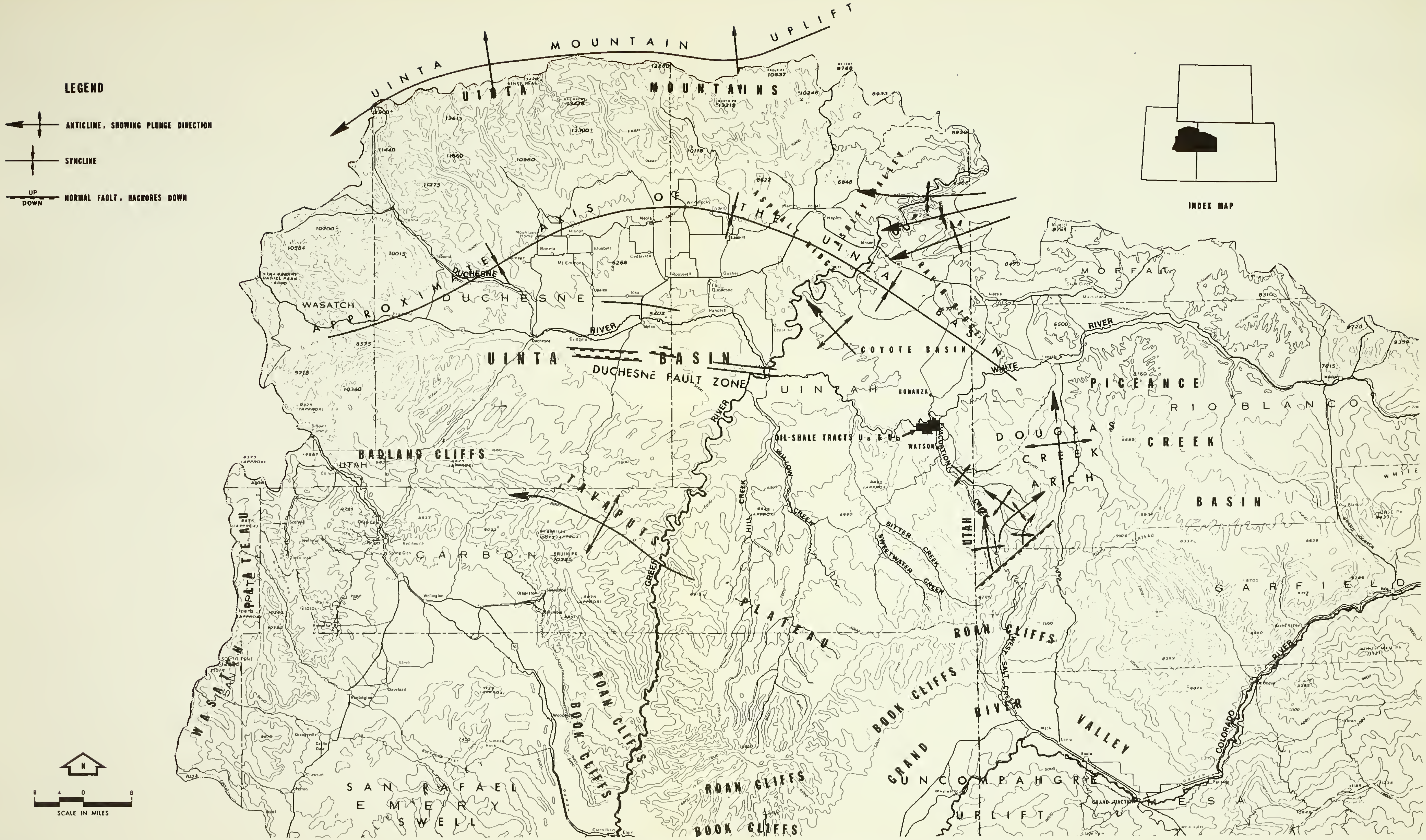
Geomorphology

In the southeastern Uinta Basin, intertributary divides between major drainages are broad and capped by resistant rock strata that dip northwestward more steeply than the plateau surface to create narrow, benchlike mesas, cuestas, and hogbacks. Northward from the White River and east of the Green River the landscape is typical badland topography consisting of many short, minor drainages with steep angular slopes, but only moderate relief. This area is prone to flash flooding and extreme erosion (Clark 1957).

Within the tracts the landscape is composed of a series of north-south-trending valleys separated by narrow, elongated mesas. Proceeding from east to west, three dominant ridge sections trend just west of north, north, and just east of north. The maximum dimensions of these landforms are oriented perpendicularly to the direction of the White River. A mesa interfluve with elevations of between 1,646 m and 1,707 m (5,400 ft and 5,600 ft) lies in an east to west transect through the central portion. The mesa slopes downward to a bench with elevations of between 1,585 m and 1,646 m (5,200 ft and 5,400 ft) and slopes down to Evacuation Creek. Continuing westward, the topography rises to elevations of between 1,646 m and 1,707 m (5,400 ft and 5,600 ft) and again drops to Southam Canyon. West of Southam Canyon, elevations increase to over 1,737 m (5,700 ft) and then slope downward to Asphalt Wash, which is generally below 1,524 m (5,000 ft).

Several types of weathering processes are evident on the tracts. Dilitation, or "shrink-swell," is apparent in the mud cracks in canyon bottoms; and chemical weathering by solution, oxidation, and carbonation is responsible in part for the formation of rock windows. The carbonation of calcium carbonate, calcium bicarbonate, and sodium bicarbonate in the sandstone and marlstone beds causes solution cavities throughout surficial outcrops of the Uinta Formation and the Parachute Creek Member of the Green River Formation. Mass wasting is evident in areas adjacent to drainages and near mesas where large blocks of rock have broken off along well-defined fractures. The action of sheet wash deposits colluvium on slopes and piles debris upgradient from vegetation on slopes. Gully erosion is also prevalent. In addition, large amounts of sediment are picked up by water flowing down Asphalt Wash, Southam Canyon, and Evacuation Creek during occasional high-intensity summer thunderstorms. Their tributaries partially contribute to the sediment load.

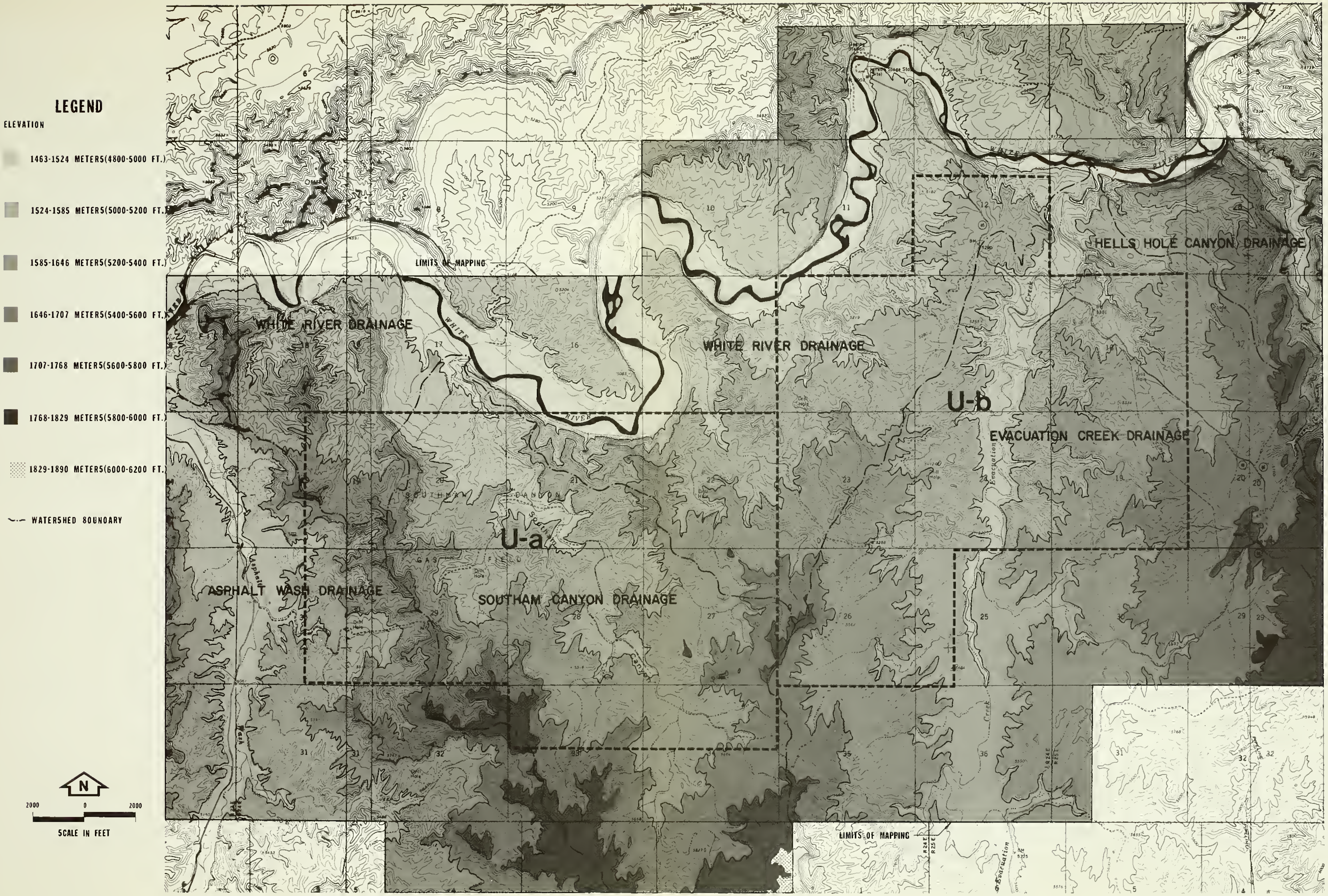
A wider range of slope gradients occurs on Tract U-a; slope gradients on Tract U-b are generally more gentle (Figure V-8). The steepest slopes in the tracts are adjacent to Evacuation



vtn

MAJOR TECTONIC FEATURES OF THE UINTA BASIN REGION

FIGURE V-6


LEGEND
ELEVATION
1463-1524 METERS (4800-5000 FT.)
1524-1585 METERS (5000-5200 FT.)
1585-1646 METERS (5200-5400 FT.)
1646-1707 METERS (5400-5600 FT.)
1707-1768 METERS (5600-5800 FT.)
1768-1829 METERS (5800-6000 FT.)
1829-1890 METERS (6000-6200 FT.)
WATERSHED BOUNDARY
N
2000 0 2000
SCALE IN FEET
LIMITS OF MAPPING
WHITE RIVER DRAINAGE
WHITE RIVER DRAINAGE
HELLS HOLE CANYON DRAINAGE
U-b
EVACUATION CREEK DRAINAGE
U-a
ASPHALT WASH DRAINAGE
SOUTHAM CANYON DRAINAGE
WHITE RIVER
LIMITS OF MAPPING

DRAINAGE BASIN SHADED RELIEF MAP

FIGURE V-7

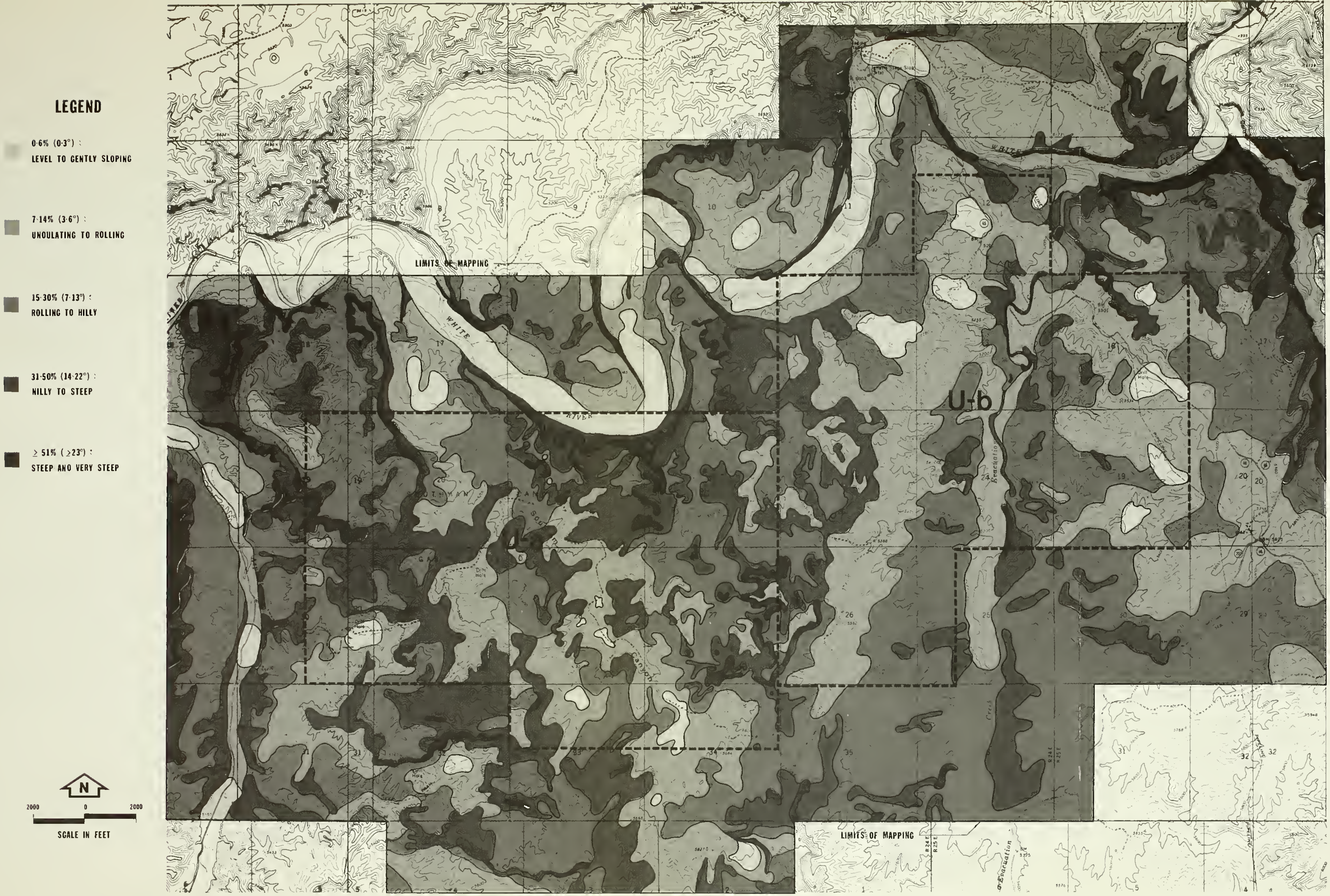

LEGEND
0-6% (0-3°) : LEVEL TO GENTLY SLOPING
7-14% (3-6°) : UNDULATING TO ROLLING
15-30% (7-13°) : ROLLING TO HILLY
31-50% (14-22°) : HILLY TO STEEP
≥ 51% (≥23°) : STEEP AND VERY STEEP
N
2000
0
2000
SCALE IN FEET
LIMITS OF MAPPING
LIMITS OF MAPPING
WHITE
RIVER
WHITE
U-b
Evacuation
Creek
Evacuation
Southam Canyon
Drill Hole
Drill Hole
Drill Hole

FIGURE V-8

SLOPE GRADIENT MAP - TRACTS U-a & U-b

Creek where it runs through Tract U-b, along the northwest-trending ridge that lies in the west portion of Tract U-a, within the southeast corner of Tract U-a, in the southwest portion of Tract U-b, and along the White River near the north borders of the tracts. The most gentle slopes occur on the mesa tops that lie parallel and along Evacuation Creek, along northern portions of Tract U-b, and along eastern portions of Tract U-b. Level-to-gently-sloping land occurs locally in the southern and southwestern portions of Tract U-a.

Rock structure has influenced the development of several erosional landforms on Tracts U-a and U-b, especially rock pinnacles and balanced rocks. These numerous and prominent forms occurring on or near ridgetops, have developed by progressive headward erosion by drainages along vertical fractures or joints. Over a long period this process leaves large isolated blocks of rock standing. The development of the large blocks is enhanced by the presence of a more resistant caprock. In addition, large rock faces on canyon walls along the White River show evidence of massive rock failures. These have occurred along vertical fractures that are generally perpendicular to the bedding.

Drainage Basin Form and Process

The overall drainage pattern of the Uinta Basin is predominantly dendritic, but there are many straight reaches along stream channels caused by the northwest-trending and northeast-trending sets of joints in the surficial rock formations. Larger streams of the basin have well-developed, meandering channels within their relatively straight, steep-walled flood channels. The Green River, flowing generally southwestward, is the master drainage within the basin. The majority of its water comes from the westward-flowing White River system and the eastward-flowing Duchesne River system.

Thirty-three percent of the tracts is in the Evacuation Creek drainage basin, 31 percent is in the Southam Canyon drainage, 30 percent drains directly into the White River, and another six percent is in the Asphalt Wash drainage (Figure V-7). The White River is the only perennial stream running through the tracts, although Evacuation Creek contains surface flow for several months of the year, mainly from ground water discharge. Southam Canyon, Asphalt Wash and tributaries of Evacuation Creek and the White River are all ephemeral.

The White River has two recognizable orders of meandering systems that probably resulted from a historical change in discharge during an earlier pluvial period in the Pleistocene Epoch. Associated with these meandering systems are genetically similar river-cut terraces that have since been dissected by tributaries of the White River.

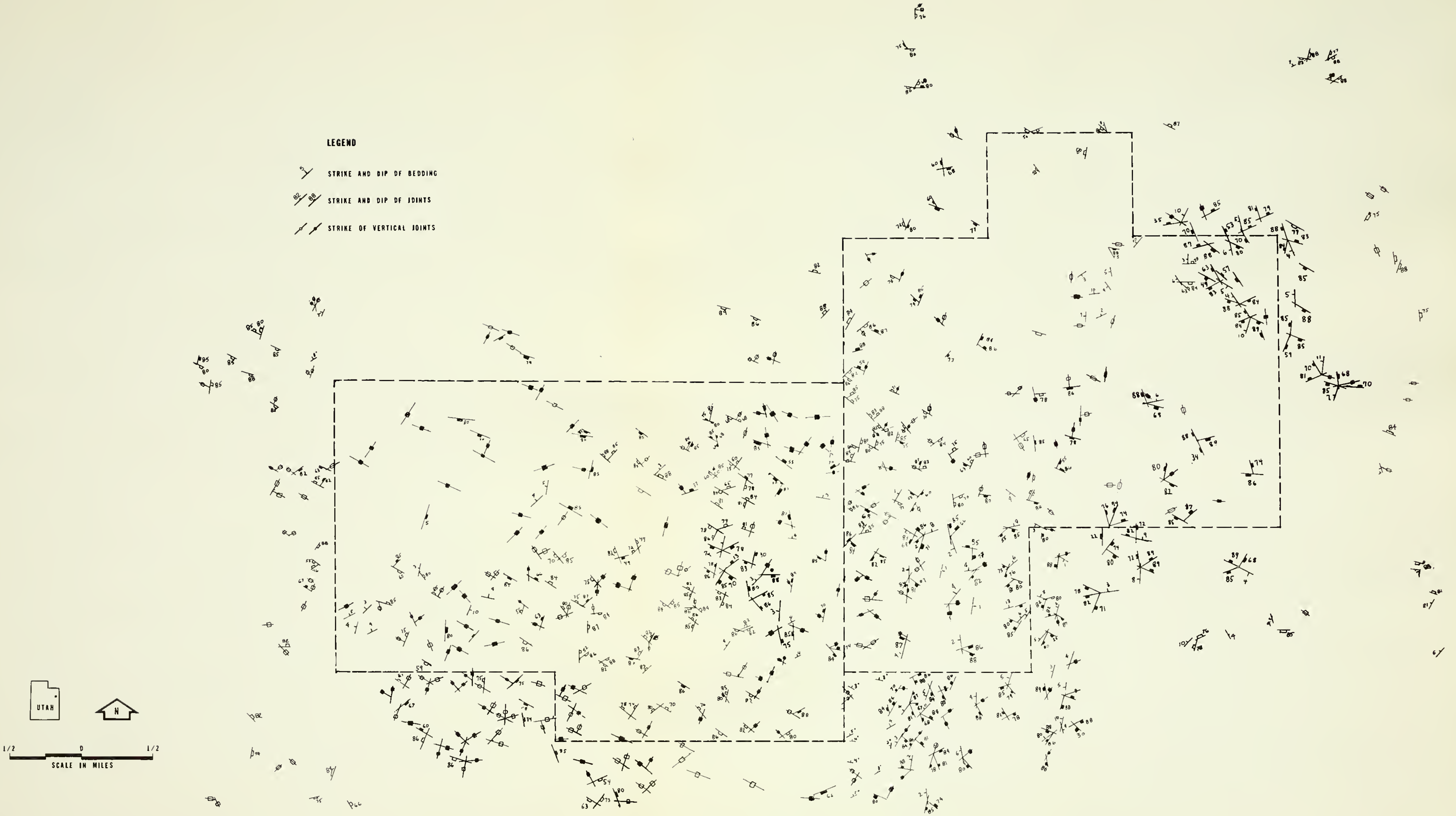
Several factors influence drainage and pattern on the tracts. Surficial outcrops of the Parachute Creek Member of the Green River Formation have a higher drainage density than that of the Uinta Formation. Orientations of relatively straight tributaries correlate strongly with the joint (rock fracture) orientation pattern in NE¼, Sec. 22 T10S, R24E, and the lower half of Southam Canyon (Figures V-7, V-9, and V-10). The more level portions of land near the river have a fine-textured (dissected) drainage density while upland areas of the Uinta Formation remain relatively coarse textures (undissected).

Fluvial landforms along the White River are dominated by point bars, longitudinal channel bars, and cut banks. The deepest pools occur on the outside of the stream channel where the meander loops have the greatest radius of curvature. Small alluvial fans exist where Evacuation Creek and lesser tributaries join the White River.

b. Geologic History

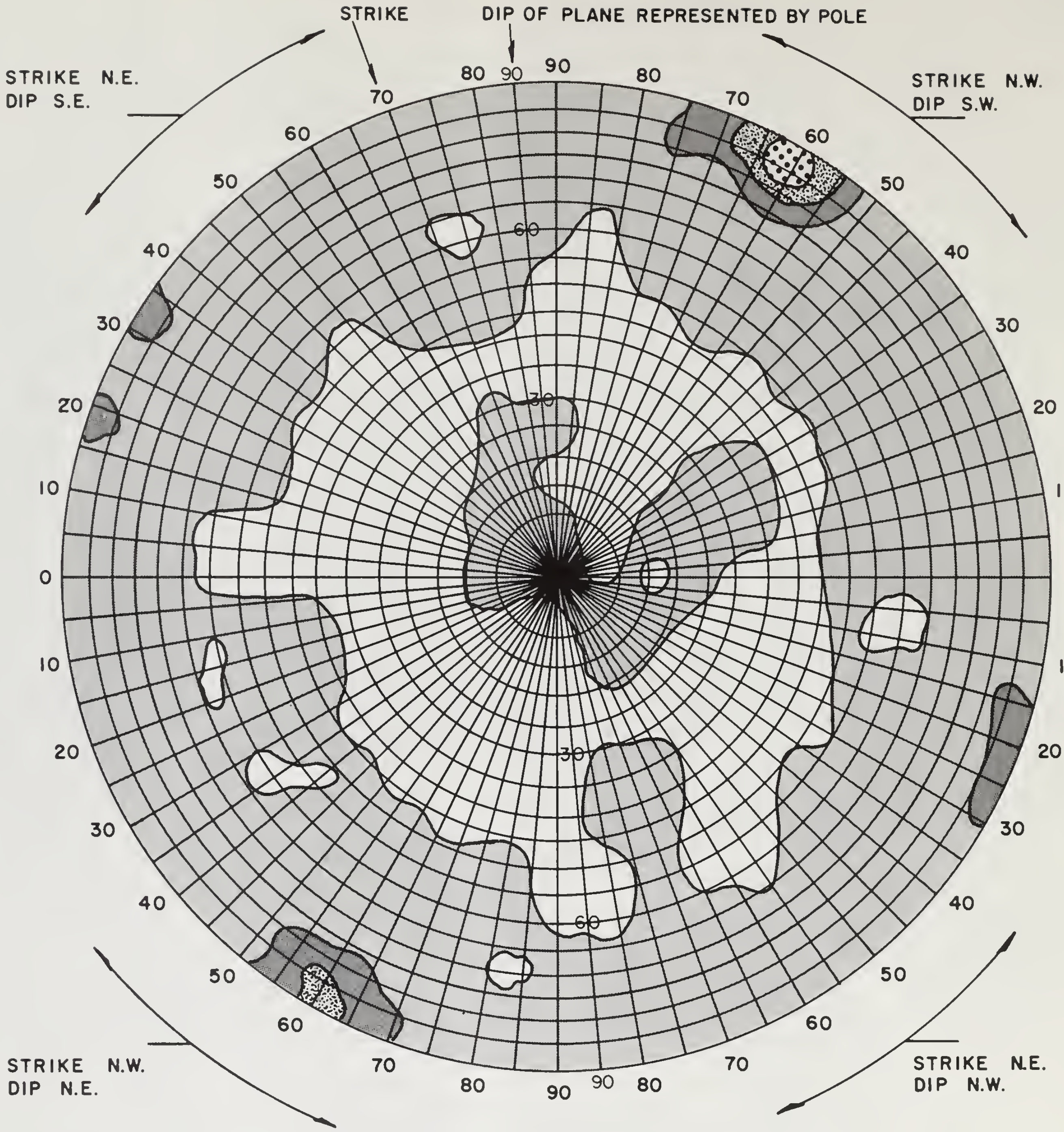
The area now encompassed by the Uinta Basin has been above sea level since the end of the Cretaceous Period. In its early stages of formation, during the Paleocene Epoch, the basin was actually the northeastern portion of a much larger basin that spread over most of Utah. The southern portion of this basin was partially filled by ancient Lake Flagstaff. As the Lake Flagstaff basin gradually filled with sediments and began to elevate regionally along its southern margin, the area northward, including the Uinta Basin, progressively subsided and filled with water to become ancient Lake Uinta. Beginning with the Early Eocene Epoch, this lake spread out to cover the entire Uinta and Piceance Creek Basin and possibly connected with another large lake that covered most of southwestern Wyoming. By the close of the early Eocene Epoch, this lake basin had filled with sediments from the surrounding highlands, Lake Uinta had dried up, and the Uinta Basin had achieved its present configuration.

The sequences of strata that crop out in this region reflect the different stages of the basin's evolution. The oldest sediments deposited during the initial stages of basin formation, constitute the Wasatch Formation. These sediments were deposited primarily along streams flowing southward from the Uinta Mountains area and along deltas of streams on the northern edges of ancient Lake Flagstaff. While Lake Uinta existed in its maximum dimensions the Green River Formation sediments and organic matter accumulated on the lake bottom. As the lake size diminished because of further rise of the Uinta Mountains and the Douglas Creek Arch, alluvial sediments of the Uinta Formation and Duchesne River Formation were



STRUCTURAL GEOLOGIC MAP OF OIL-SHALE TRACTS U-a & U-b, UINTAH COUNTY, UTAH

FIGURE V-9



PURPOSE

ANALYSES OF PRINCIPLE JOINT SYSTEMS

AVERAGES

PRIMARY SET ... N62W/86SW

SECONDARY SETS ... N22E/88NW
N18E/88SE
N33E/87SE

LEGEND

CONTOUR INTERVAL IN PERCENT OF TOTAL SAMPLE

░	0-5
▒	5-10
▨	10-15
⁘	15-20

COUNT DIAGRAM OF POINTS REPRESENTING JOINT ORIENTATIONS, TRACTS U-a & U-b

FIGURE V-10

spread over the surface of the Uinta Basin by meandering streams that flowed toward the lower, central portions of the basin (McDonald 1972).

c. Stratigraphy

Rock formations studied in detail as a part of the first year environmental study were deposited during the Eocene Epoch and the Quaternary age. The outcrop pattern of rocks in the vicinity of the tracts is shown on Figure V-11; a regional cross section through the tracts is shown on Figure V-12. The most complete stratigraphic sequence of well-exposed rocks in this vicinity is accessible within Hells Hole Canyon, just east of the tracts.

Eocene Epoch

Wasatch Formation: The Wasatch Formation in the Uinta Basin consists of reddish-brown-to-gray lenticular stream-channel sandstones interbedded with red, purple, and green continental mudstone deposits and minor amounts of conglomerate and limestone. The formation thickens progressively from about 76 m (250 ft) in outcrops along the southwestern margin of the Douglas Creek Arch north and northwest to a maximum of about 1,067 m (3,500 ft) in the subsurface along the axis of the Uinta Basin. The top of the Wasatch Formation represents a transition upward from a predominantly fluvial environment to the lacustrine depositional environment in which the Green River Formation was laid down (McDonald 1972).

Geologic exploration of Tracts U-a and U-b indicates that the Wasatch Formation does not crop out at the surface on-site. Beneath the tracts the uppermost portion of the formation ranges in depth from approximately 457 m (1,500 ft) to 762 m (2,500 ft) below ground surface (see Figures V-12 through V-14). The nearest surface exposure of the Wasatch Formation to the site occurs 3.5 km (2.2 mi) east of Tract U-b in Hells Hole Canyon.

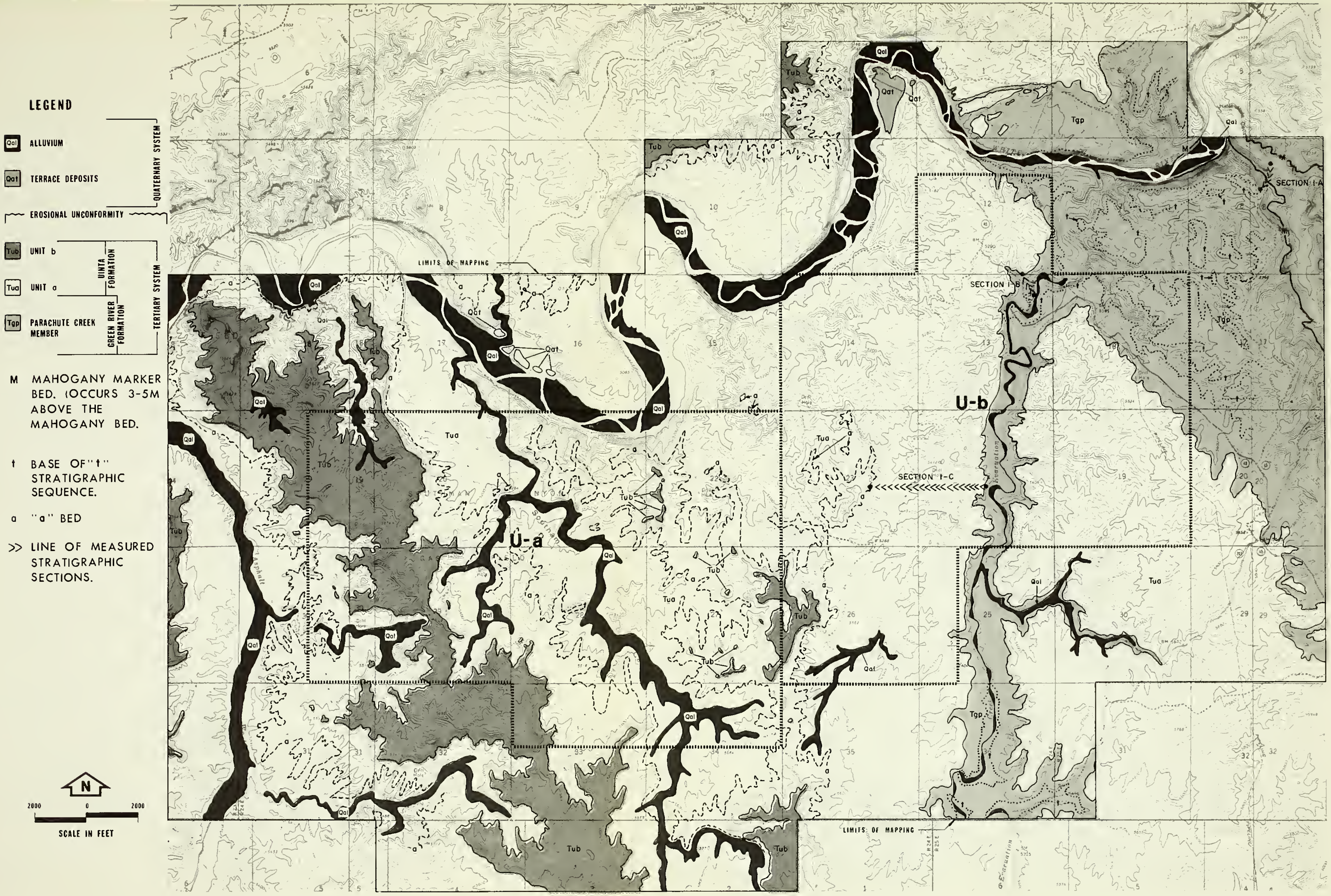
Green River Formation: The Green River Formation consists primarily of light-gray-to-dark-gray, hard, brittle marlstone and oil shale interbedded with relatively minor amounts of brown sandstone, siltstone, nahcolite nodules, and thin volcanic tuff beds. The formation ranges in thickness from a maximum of 427 m (1,400 ft) in extensive outcrops around the southern perimeter of the Uinta Basin (Cashion 1967) to a maximum of 2,195 m (7,200 ft) in the subsurface along the depositional axis of the basin near Duchesne, Utah (Picard

1955). The total thickness of the formation beneath the tracts is approximately 488 m (1,600 ft).

The uppermost portion of the Green River Formation is exposed along Evacuation Creek and in the far northeastern edge of Tract U-b (Figure V-11). Resistant units within the formation are responsible for the rugged topography and high relief of the Tavaputs Plateau, Roan Cliffs, and Hells Hole Canyon. Bradley (1931) described the origin and occurrence of the Green River Formation and further divided it into four members. In ascending order they are the Douglas Creek Member, Garden Gulch Member, Parachute Creek Member, and Evacuation Creek Member. These divisions were originally based on lithologic dissimilarities of units mapped in several different localities, but more recent detailed work by Cashion and Donnel (1974) has led to a revised subdivision and nomenclature for the Green River Formation. The term "Evacuation Creek Member" is no longer used because of the difficulty in distinguishing that member from the Parachute Creek Member; therefore, Evacuation Creek strata are now included within the Parachute Creek Member.

Compared with other parts of the Green River Formation, the Douglas Creek Member consists of relatively large amounts of sandstone and limestone and contains only a small amount of oil shale. Outcrops of the Douglas Creek Member in Hells Hole Canyon just east of the tracks and in Evacuation Wash just southeast of the tracts reveal that the member is composed primarily of light yellowish-brown and light gray oolitic limestone interbedded with gray-to-brown sandstone and siltstone. (Oolites are spherical calcium carbonate grains that precipitate directly from water.) Limestone in this unit was deposited in the fresh water of ancient Lake Uinta and contains many algal stromatolite structures and ripple marks, which indicate that its deposition took place in shallow water. The member also contains minor amounts of marlstone, shale, and oil shale in the vicinity of the tracts. Its thickness ranges from about 61 m (200 ft) in outcrops along the south and southwest margins of the Uinta Basin to a total of about 259 m (850 ft) in the vicinity of the tracts. Moving northwest toward the axis of the Uinta Basin, the member increases up to a maximum thickness of 914 m (3,000 ft) in the subsurface (Abbott 1957). As shown on Figures V-12 through V-14 the member is not exposed at the surface within the tracts but lies below in depths ranging from approximately 381 m (1,250 ft) to 533 m (1,750 ft). Its maximum thickness beneath the tracts is about 198 m (650 ft).

Although no exploratory borings completed for the project have penetrated the Douglas Creek Member entirely, a few holes--P-2, P-4 and G-16--reach its uppermost strata. Borehole G-16, approximately 9.7 km (6 mi) south of the southeast corner of Tract U-b along Evacuation Creek, was drilled into the upper

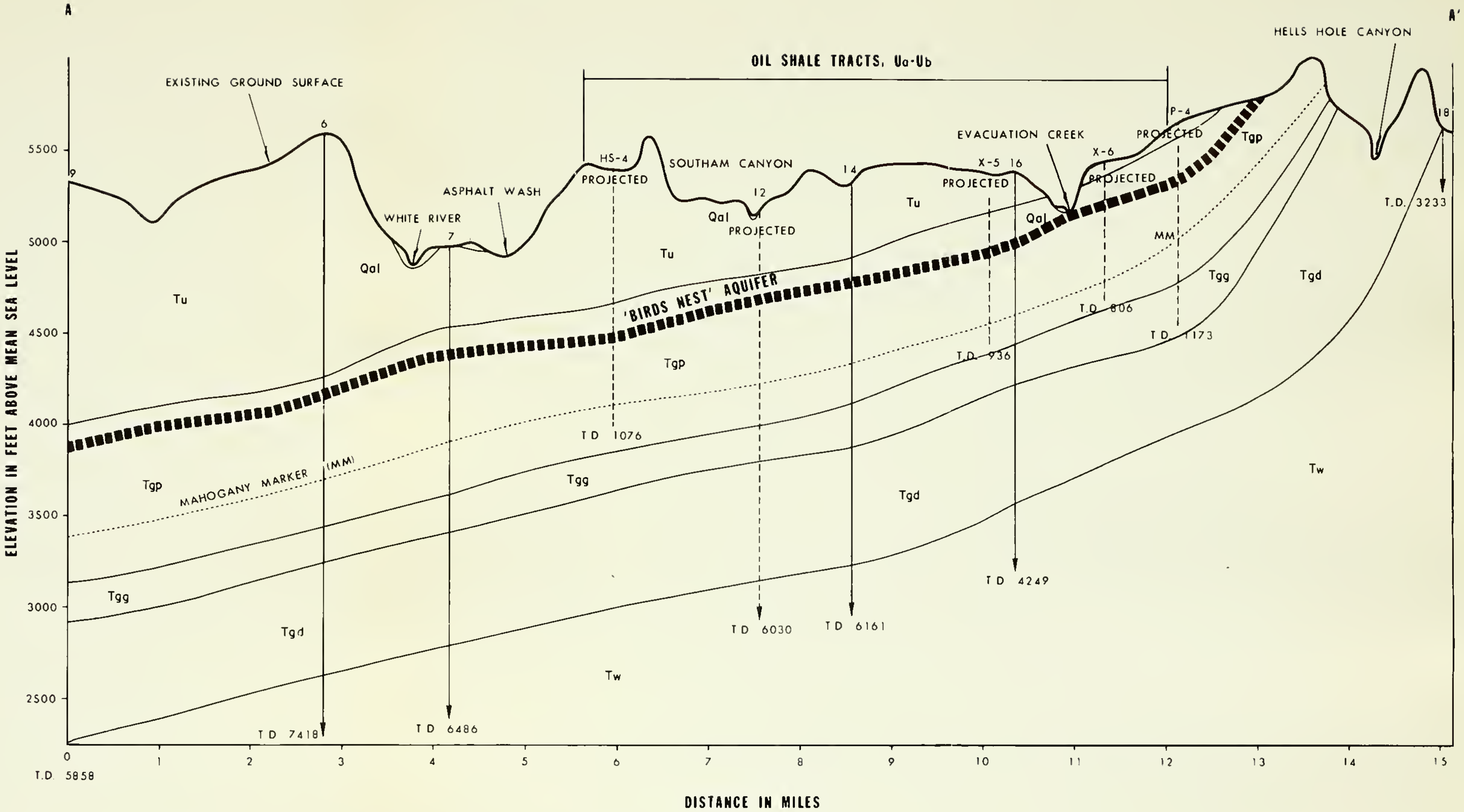


GEOLOGIC MAP OF OIL-SHALE TRACTS U-a & U-b , UINTA COUNTY, UTAH

FIGURE V-11

LEGEND

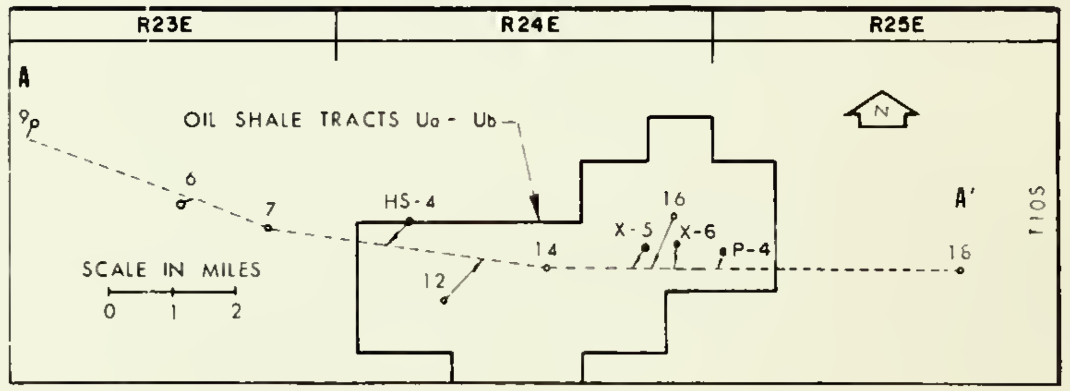
	QUATERNARY	
Qal	ALLUVIUM	
	TERTIARY	
Tu	UINTA FORMATION	
Tgp	PARACHUTE CREEK MEMBER	GREEN RIVER FORMATION
Tgg	GARDEN GULCH MEMBER	
Tgd	DOUGLAS CREEK MEMBER	
Tw	WASATCH FORMATION	
X-5 •	CORE HOLES, WITH PROJECT NO. DESIGNATION	
•16	OIL AND GAS TEST WELLS WITH GEOPHYSICAL LOGS	



OIL AND GAS TEST WELLS WITH GEOPHYSICAL LOGS

MAP NO	OPERATOR	DESCRIPTION
9	BELCO	TEXOTA #1
6	EL PASO N.G CO	SOUTHAM CANYON #3
7	SHELL OIL	SOUTHAM CANYON #7
12	EL PASO N.G CO	SOUTHAM CANYON #4
14	MOAB DR CO	GEM #1
16	CONTINENTAL OIL CO.	#1 AA 120 WATSON
18	OIL INC.	BONANZA #2

LOCATION OF CROSS-SECTION

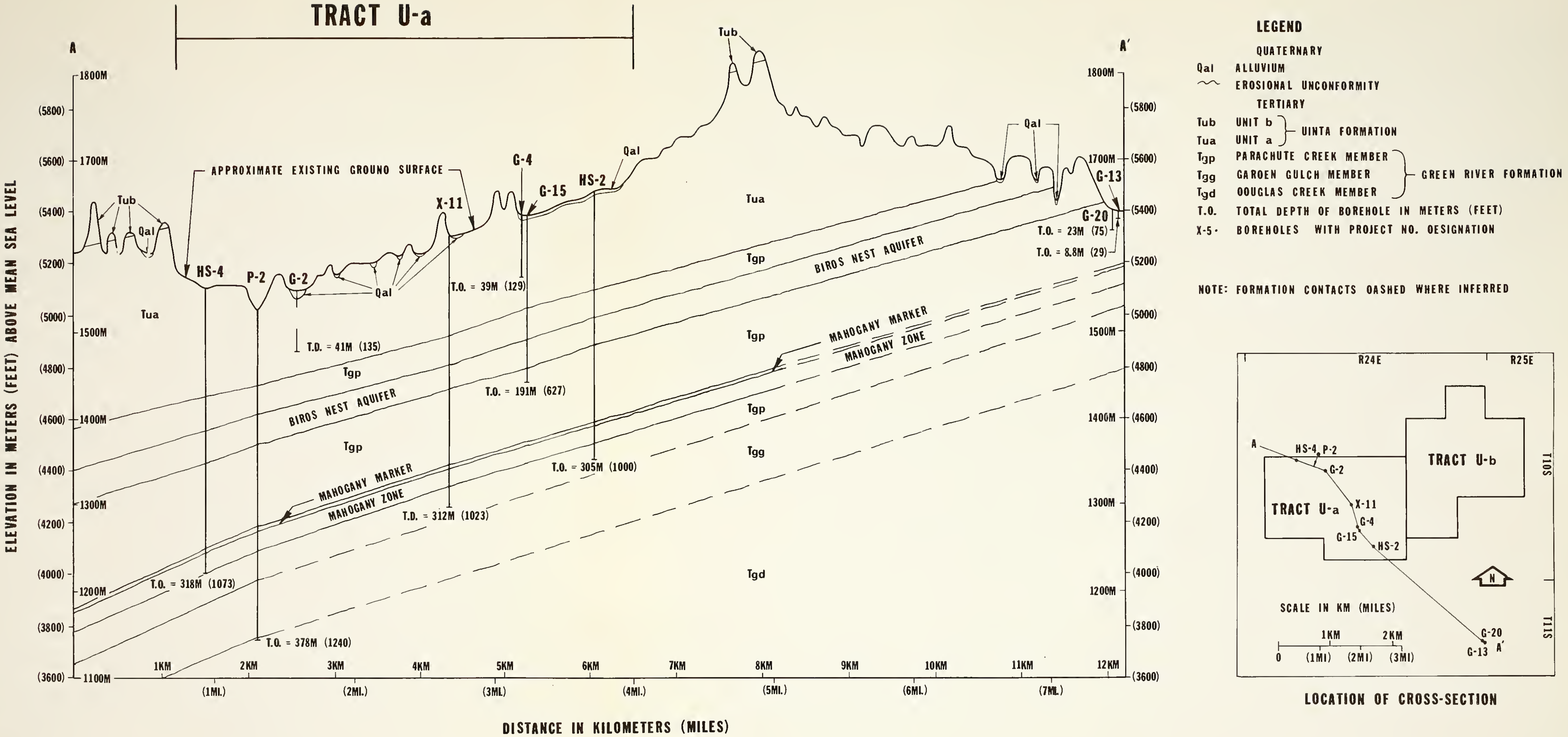


NOTE : T.D. IS TOTAL DEPTH OF BORE HOLE IN FEET

REGIONAL GEOLOGIC CROSS-SECTION

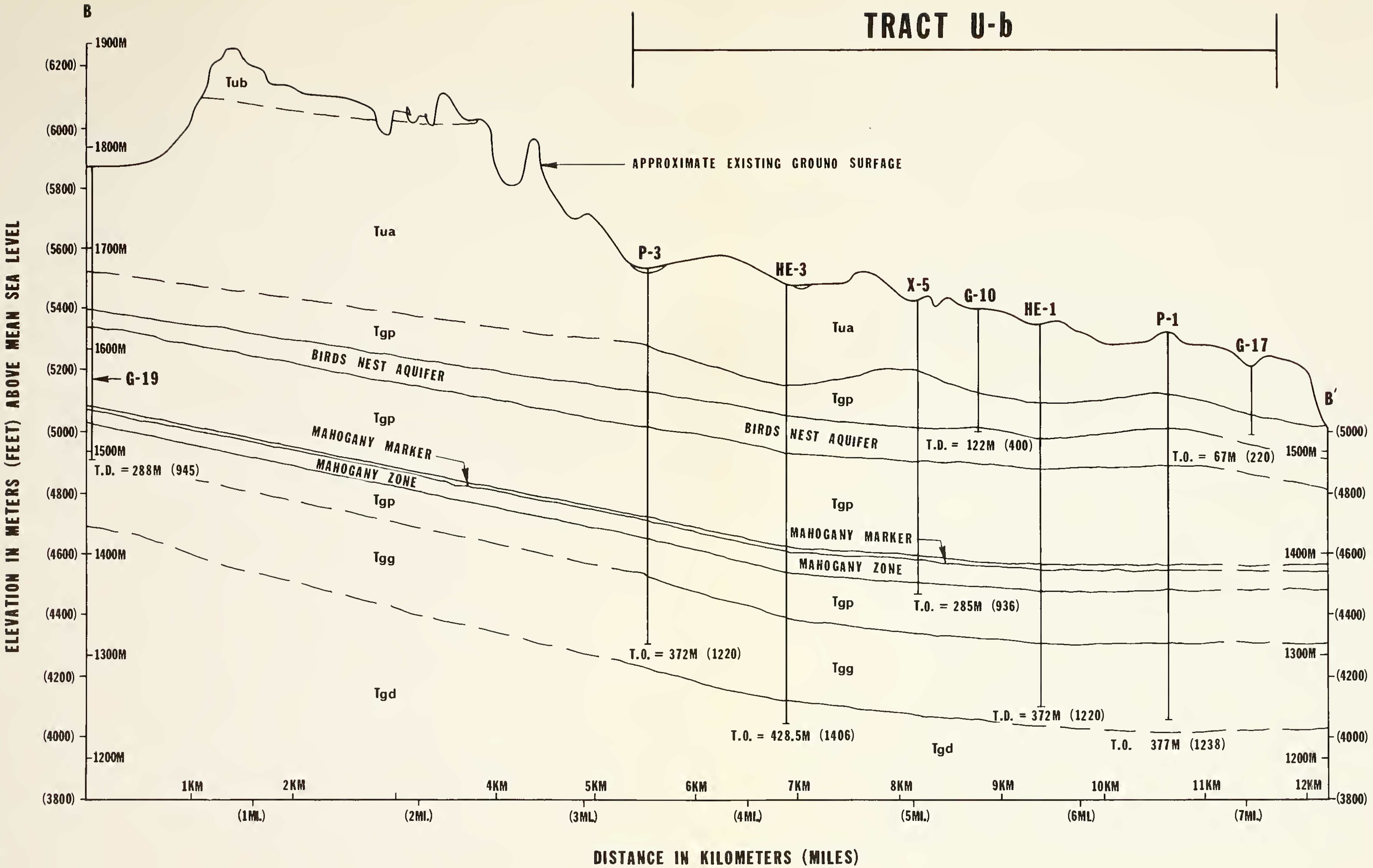
THROUGH OIL SHALE TRACTS Ua-Ub

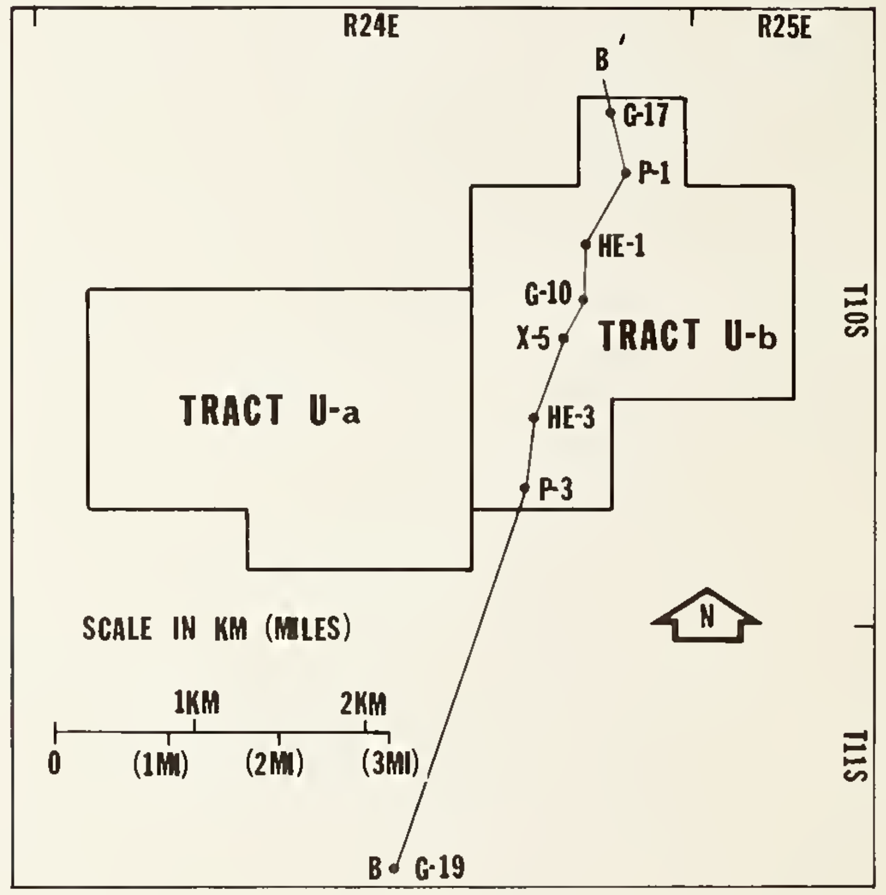
FIGURE V-12



GEOLOGIC CROSS-SECTION THROUGH OIL SHALE TRACT U-a

FIGURE V-13





LOCATION OF CROSS-SECTION

GEOLOGIC CROSS-SECTION THROUGH OIL SHALE TRACT U-b

FIGURE V-14

portion of the member and was then completed as an observation well. Water now flowing from the well indicates that the Douglas Creek strata may contain extensive water bearing strata beneath the tracts.

The Garden Gulch Member consists primarily of gray and brown marlstone strata with imbedded and organic matter and minor amounts of siltstone, sandstone, and thin beds of oil shale. Near the tracts, outcrops occurring within Hells Hole Canyon are about 70 m (230 ft) thick, decreasing in thickness to the northeast and southwest and probably grading into the Parachute Creek Member. The Garden Gulch Member is not exposed on the tracts but is found below depths ranging from about 244 m (800 ft) to 366 m (1,200 ft). Its thickness varies from 67 m (220 ft) to 76 m (250 ft) beneath the tracts (see Figures V-12 through V-14).

The Parachute Creek Member includes the mahogany zone which is the most economically important sequence of oil shale strata in the vicinity of the tracts. The member lies within the upper Green River Formation. Its lithology is predominantly calcium carbonate mudstone, or marlstone, and dolomite containing abundant organic matter interbedded with minor amounts of siltstone, sandstone, and altered volcanic tuff beds. Near the tracts, outcrops along the southeast perimeter of the Uinta Basin attain a maximum thickness of 274 m (900 ft); and like the other tertiary formations in the Uinta Basin, it thickens progressively in the subsurface from near the tracts toward the northwest (Figure V-12). Strata within the upper 66 m (200 ft) or so of the Parachute Creek Member are exposed within the eastern portion of the tracts, as shown on Figure V-11. The majority of the member, however, lies below the surface within the tracts, as shown on the geologic cross sections (Figures V-12 through 14). The strata dip at approximately 32 m/km (170 ft/mi) to the northwest, and the thickness of the member averages 222 m (730 ft) beneath the site. A measured stratigraphic section of the upper portion of the Parachute Creek Member (Figure V-15) illustrates the physical character of the strata in this member and shows the relative positions of important marker beds and the richest oil shale zone.

The mahogany marker is a persistent and widespread key bed within the Parachute Creek Member commonly used to mark the stratigraphic position of the principal oil shale zone. It is an analcitized volcanic tuff bed that averages 15 cm (6 in) thick and lies 3 m to 5 m (9 ft to 15 ft) above the mahogany bed, the richest oil shale bed in the basin. The mahogany marker weathers to orange-brown rectangular blocks and lies within the upper portion of the mahogany zone which outcrops as a light-gray-to-tan resistant ledge (Cashion 1967). A structural contour map of the mahogany marker defining the orientation of strata within the primary mining zone is shown on Figure V-16. This marker bed dips at about 28 m/km to 47 m/km (150 ft/mi to 200 ft/mi) to the northwest. Since the mahogany oil shale bed lies just below this marker bed, approximate depth estimates to the mining zone may be made rapidly from this map. The mahogany oil shale zone averages about 30.5 m (100 ft) thick beneath the site. The proposed mining zone will extend from about 6.1 m (20 ft) above to about 12.2 m (40 ft) below the mahogany marker.

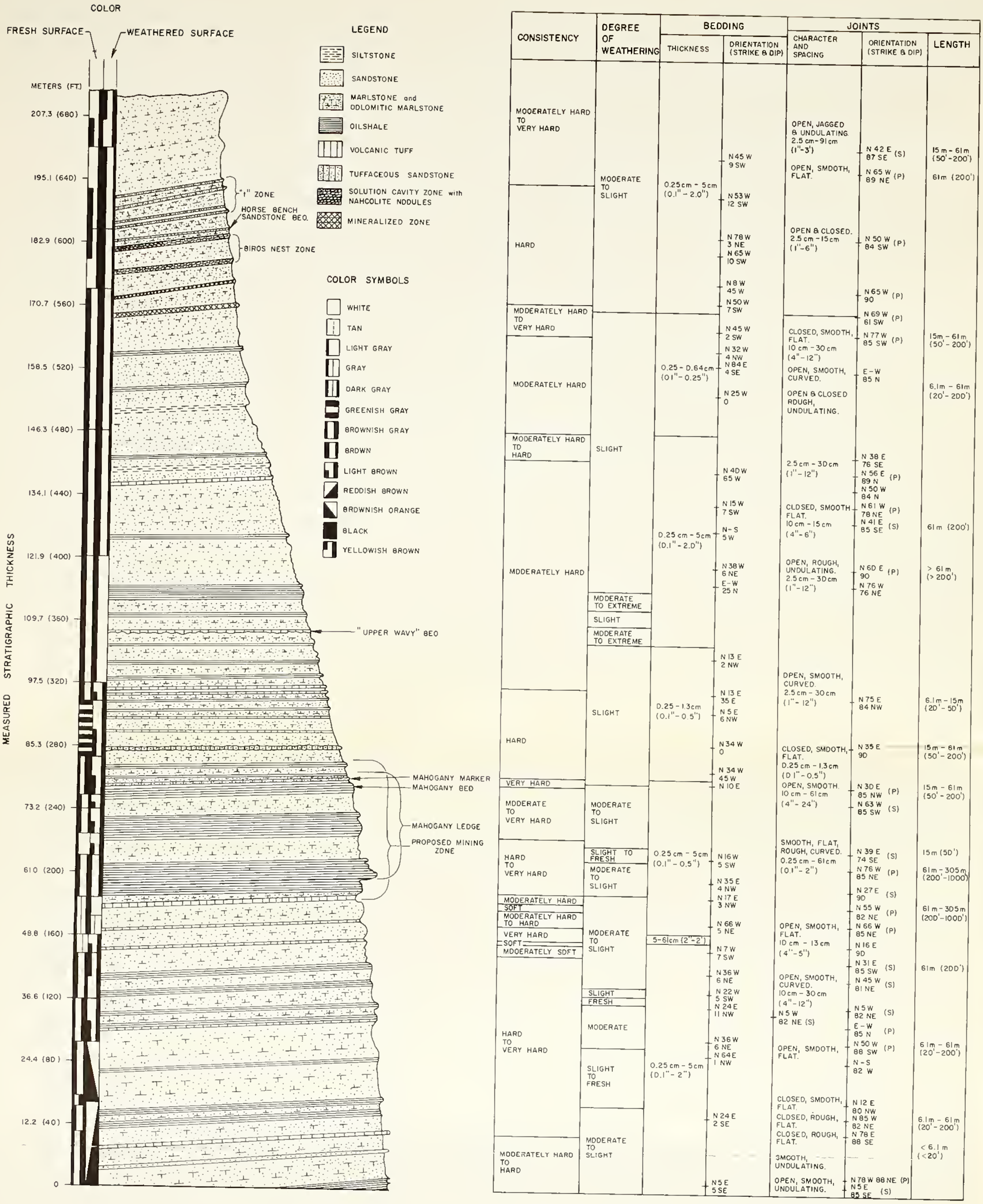
A remarkably distinctive zone lies near the top of the Parachute Creek Member. It is known informally as the "bird's nest zone" because of its many ellipsoidal cavities formed by leaching out of nahcolite--a soluble sodium-bicarbonate mineral--from a matrix of predominantly siltstone and marlstone (Cashion 1967). This zone is the primary aquifer above the mahogany zone in the vicinity of the tracts (see "Ground Water" Section II.C.2.b.).

Another prominent ledge-forming light-brown sandstone unit, recognizable in outcrops of the Parachute Creek Member, and is equated with the "horse bench sandstone bed of Cashion & Brown (1956)." It reaches a maximum thickness of about 16 m (55 ft) at its originally designated "type locality" 22 km (35 mi) west of the tracts, and occurs approximately 43 m to 50 m (140 ft to 165 ft) below the top of the Parachute Creek Member.

In the vicinity of the tracts the horse bench sandstone bed varies from about 0.7 m to 3 m (2 ft to 10 ft) in thickness. Along Evacuation Creek within the tracts this unit is composed of very fine sandstone and siltstone. Surface exposures of the horse bench sandstone are typically covered with white salt deposits, which indicate ground water seepage and evaporation from the outcrops. Since this sandstone bed lies just above, and is in hydraulic contact with, the water-bearing bird's nest zone, it is included within the bird's nest aquifer zone (see "Ground Water" Section II.C.2.b.).

A number of volcanic tuff beds occur throughout the Parachute Creek Member; and a particularly conspicuous sequence of thick, light-gray tuffaceous sandstone beds occur above the bird's nest zone. These beds create a yellowish-orange-weathering ledge-forming sequence of marlstone and siltstone designated the "t" zone. The outcrop pattern of this zone is shown on Figure V-11.

Uinta Formation: The most extensively exposed sequence of strata in the central Uinta Basin is the Uinta Formation, which overlies the Green River Formation. The lithology of the Uinta Formation at different locations throughout the basin is extremely variable, ranging from continental boulder conglomerates along the northwestern perimeter of the basin

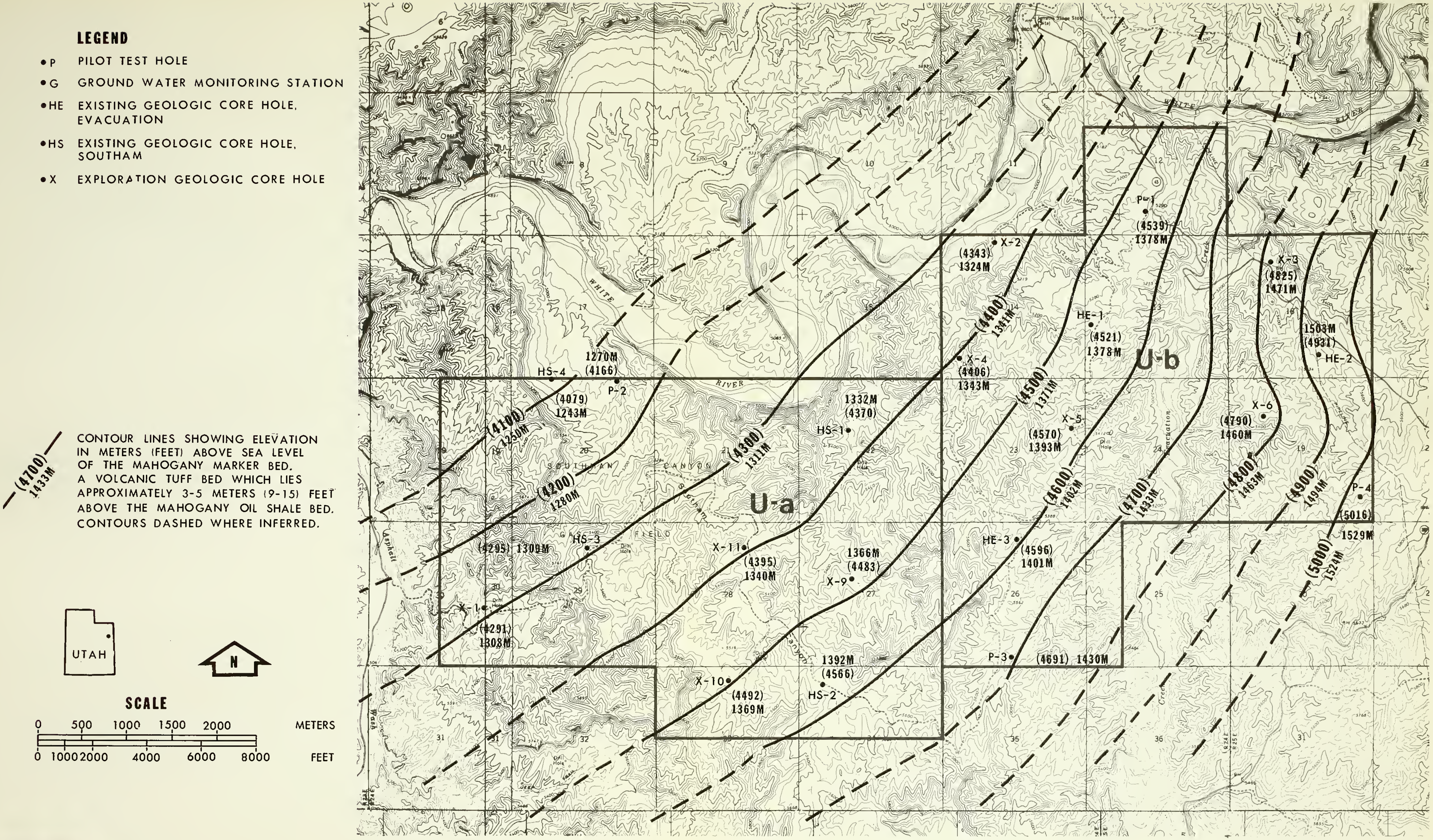


NOTES: (P) = PRIMARY JOINT SET.
(S) = SECONDARY JOINT SET.
SEE GEOLOGIC MAP OF TRACTS Ua - Ub FOR THE LOCATION OF THE SECTION.
SEE TABLE I FOR DEFINITIONS OF THE TERMS USED TO DESCRIBE THE PHYSICAL CHARACTERISTICS OF BEDROCK.

MEASURED STRATIGRAPHIC SECTION OF THE UPPER PORTION OF THE PARACHUTE CREEK MEMBER OF THE GREEN RIVER FORMATION (SECTION 1-A), HELLS HOLE CANYON, UTAH.

FIGURE V-15

1517-19 7-22-75



LEGEND

- •P PILOT TEST HOLE
- •G GROUND WATER MONITORING STATION
- •HE EXISTING GEOLOGIC CORE HOLE, EVACUATION
- •HS EXISTING GEOLOGIC CORE HOLE, SOUTHAM
- •X EXPLORATION GEOLOGIC CORE HOLE

(4700) 1433M CONTOUR LINES SHOWING ELEVATION IN METERS (FEET) ABOVE SEA LEVEL OF THE MAHOGANY MARKER BED. A VOLCANIC TUFF BED WHICH LIES APPROXIMATELY 3-5 METERS (9-15) FEET ABOVE THE MAHOGANY OIL SHALE BED. CONTOURS DASHED WHERE INFERRED.

SUBSURFACE STRUCTURAL CONTOUR MAP OF THE MAHOGANY MARKER BED, TRACTS U-a & U-b

FIGURE V-16

to brown stream-channel and deltaic sandstones interbedded with minor amounts of greenish-gray shale along the eastern Uinta Basin. Thinly-bedded lake deposits of shale and dolomite that contain salt crystal molds occur in the central basin interior within the formation that were laid down as ancient Lake Uinta was drying up (Dane 1954). The thickness of the Uinta Formation ranges from zero along the eroded northwestern and western part of the Uinta Basin; to 457 m (1,500 ft) in the vicinity of the tracts (Cashion and Brown 1956); and up to a maximum of 1,524 m (5,000 ft) near the depositional axis of the Uinta Basin (McDonald 1972).

Within the tracts the Uinta Formation crops out extensively (Figure V-11) where it attains a maximum thickness of roughly 305 m (1,000 ft). Previous investigators divided the formation into two units, Unit a and Unit b, based primarily on the position of a 0.61 m to 1.8 m (2 ft to 6 ft) thick tuffaceous sandstone bed at the base of Unit b (designated "Tub" on Figure V-11). Unit a, designated "Tua," extends downward from the base of Unit b to the top of the Green River Formation. The lithology of both units is generally stream deposited fine-grained sandstone and siltstone interbedded with minor amounts of shale and conglomerate.

The physical characteristics of the strata that constitute Unit a are illustrated and described on Figure V-17. In aerial views the general color of Unit a is light reddish-brown, whereas Unit b is generally light yellowish-brown. In addition, Unit b contains some beds of dark reddish-brown and yellowish-gray shale that are absent in Unit a.

As described by Cashion and Donnel (1974) and shown on Figure V-11, there is a prominent tuffaceous sandstone bed (designated "a") within Unit a that lies about 56 m (185 ft) below the Unit a-Unit b contact. This 2 m (6 ft) thick, yellow-to-orange bed stands out boldly in cliffs and benches.

Duchesne River Formation: On the northeastern margin and in the north-central part of the Uinta Basin, the Uinta Formation is covered by younger, more reddish stream-deposited strata that contain significant amounts of sandstone and conglomerate. These strata, known as the Duchesne River Formation, were first described and named by Kay (1934), as referenced by McDonald (1972). According to McDonald (1972), the maximum thickness attained is about 610 m to 762 m (2,000 ft to 2,500 ft) near the Uinta Basin axis. This formation does not outcrop in the vicinity of the tracts, but its surface exposures, beginning about 8 km (5 mi) north of Bonanza, create the characteristic badland topography of the northeastern Uinta Basin.

Quaternary Period

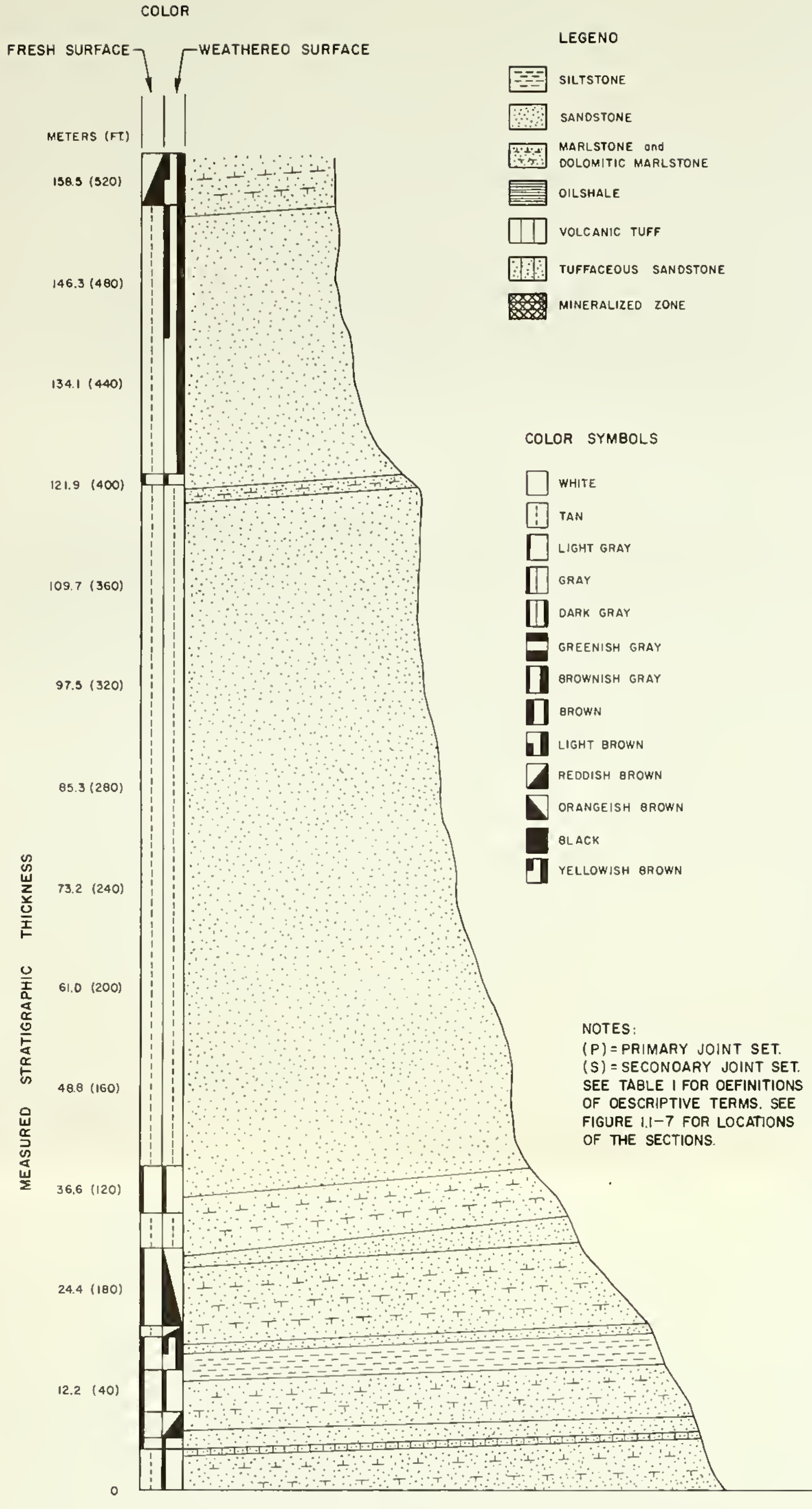
Material of the Quaternary Period occurs in the Uinta Basin mainly as alluvium composed of silt-to-boulder-sized pieces of dolomite, marlstone, sandstone, and siltstone deposited along active major drainages: the Green River, White River, and Duchesne River. Isolated patches of cemented slope-wash deposits or colluvium, are found within the canyons above major drainages. Gravel surfaces that originally formed as pediments and stream terraces are presently being eroded. These surfaces occur as isolated flat-topped hills in the northeastern and central portions of the basin. Large expanses of glacial outwash material were laid down beyond the outer limits of the moraines along the north margins of the basin at higher elevatiens.

Alluvium occurs in the tracts along Evacuation Creek Canyon, the White River, within Southam Canyon, and in isolated patches along drainages where they pass over outcrops of the Uinta Formation. The geologic map of the tracts shows the areas underlain by alluvium (Figure V-11).

The Southam Canyon alluvium, composed primarily of light-reddish-brown silt and fine sand, attains an estimated maximum thickness of 10 m (33 ft). The alluvium in Evacuation Creek Canyon occurs in patches that reach a maximum thickness of 6 m (20 ft) along the inside, downstream portions of meander loops of the creek. Since this canyon is forming by erosion down through the Uinta Formation and into the Green River Formation, the alluvium is mostly a mixture of coarse-grained, platy marlstone fragments, fine-to-medium-grained sand, and sand-sized limestone fragments. Isolated patches of alluvial material deposited on outcrops of the Uinta Formation are basically light-reddish-brown, fine, silty sand. Along the White River the alluvium is primarily light-brown fine sand with some gravel. The estimated thickness of the alluvium along the White River near the tracts is 10 m to 15 m (35 ft to 50 ft), based on the depths to bedrock encountered while drilling alluvial wells AG-2 and AG-1a.

d. Structural Geology

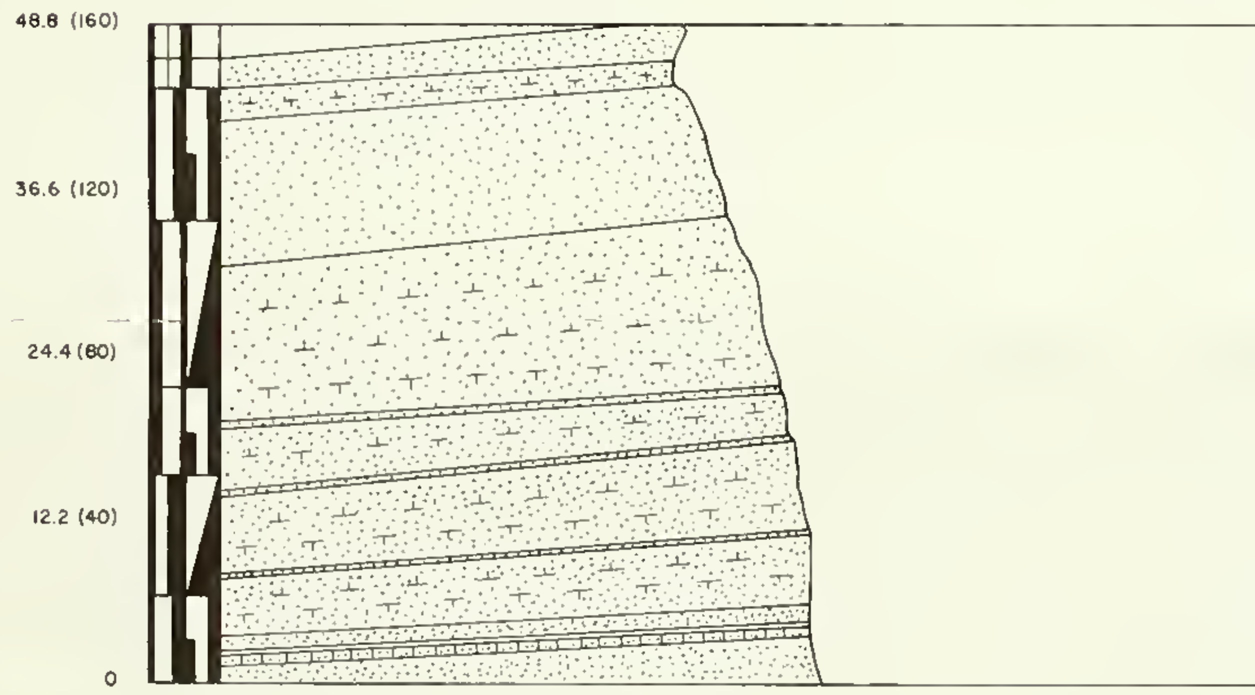
The Uinta Basin is an elongated structural depression that trends along an east-west axis about 48 km (30 mi) south and parallel to the crest of the Uinta Mountains (Figure V-6). Major structural elements bounding the basin are the Douglas Creek Arch on the east, the Uncompahgre uplift on the southeast edge, the San Rafael Swell on the southwest, and the Uinta Mountain uplift on the north.



NOTES:
(P) = PRIMARY JOINT SET.
(S) = SECONDARY JOINT SET.
SEE TABLE I FOR DEFINITIONS OF DESCRIPTIVE TERMS. SEE FIGURE I.I-7 FOR LOCATIONS OF THE SECTIONS.

CONSISTENCY	DEGREE OF WEATHERING	BEDDING		JOINTS		
		THICKNESS	ORIENTATION (STRIKE & DIP)	CHARACTER AND SPACING	ORIENTATION (STRIKE & DIP)	LENGTH
MODERATE TO HARD	MODERATE	0.64 - 5cm (1/4"-2")				
	SLIGHT	10 - 30 cm (4"-12")	N 5 E 7 NW	OPEN, SMOOTH, FLAT. 10 - 152 cm (4"-5')	N 20 E 80 SE (P) N 70 E 74 SW (S)	6.1m - 15m (20'-50') 6.1m - 12m (20'-40')
		2.5 - 30 cm (1"-12")	N 10 E 4 NW			
SOFT TO MODERATE	MODERATE TO EXTREME			OPEN, ROUGH, CURVED TO UNDULATING 10 cm - 61 cm (4"-2.0')	N 50 W 84 SW (S) N 80 E 80 SE & 78 NW (P)	< 6.1m - 15m (<20'-50') <6.1m (<20')
MODERATE TO HARD	EXTREME	0.25 - 5cm (1/10"-2")	N 14 W 5 SW N 10 W 4 SW	CLOSED, JAGGED, CURVED. 10cm - 61cm (4"-2.0')	N 15 E/90 N 70 E 72 NE	6.1 m - 61m (20'-200') 6.1 m - 61m (20'-200')
	SLIGHT TO MODERATE	0.25 - 5cm (1/10"-2")	N 10 E 5 NE	OPEN, ROUGH, UNDULATING. 10cm - 61cm (4"-2.0')	N 45 W 85 NE	<6.1m (<20')
HARD					N 45 E/90 (S) N 10 W 78 NE (P)	<6.1m (<20') <6.1m (<20')
		2.5cm (1")	22 W 11 SW	OPEN, ROUGH, CURVED. 10cm - 61cm (4"-2.0')		
MODERATE	SLIGHT					
		0.25 - 61cm (1/10"-2')				
	SLIGHT TO MODERATE		N 33 W 75 W N 5 W 11 SW	OPEN, ROUGH, FLAT.	N 55 W 90 (P)	<6.1m (<20')
SOFT TO MODERATE				OPEN, ROUGH, UNDULATING. < 10cm - 30cm (< 4"-12")	N 76 E 87 SE (S) N 59 W 79 SW (P)	6.1m - 15m (20'-50') <6.1m - 15m (<20'-50')
MODERATELY HARD						
		5cm - 61cm (2"-2')	N 15 W 3 SW N 15 W 4 SW			
MODERATELY HARD TO VERY HARD			N 15 W 4 SW			
MODERATELY HARD		0.25 - 1.3cm (1/10"-1/2")	N 5 W 18 SW	CLOSED, SMOOTH, CURVED. < 10cm - 30cm (<4"-12")		
HARD		5cm - 61cm (2"-2')				
MODERATELY HARD		0.25 - 1.3cm (1/10"-1/2")		OPEN, ROUGH, UNDULATING 10cm - 30cm (4"-12")		
MODERATELY HARD TO HARD	MODERATE TO EXTREME	5 cm - 61cm (2"-2')	N 80 W 8 NE	OPEN, SMOOTH, FLAT. 10cm - 30cm (4"-12")	N 20 E 72 SE (P) N 10 E 90 (S)	15m - 61m (50'-200') 6.1m - 15m (20'-50')
MODERATELY HARD	VERY SLIGHT	1.3 - 25 cm (1/2"-10")				
MOD. HARD - V. HARD	SLIGHT TO MODERATE	0.25 - 30cm (1/10"-1")				
MODERATELY HARD		0.25 - 1.3cm (1/10"-1/2")		OPEN, SMOOTH, FLAT.	N 26 E 5 NW (P) N 8 W 86 SW (S)	15m - 61m (50'-200') 15m - 61m (50'-200')

MEASURED STRATIGRAPHIC SECTION OF THE UINTA FORMATION (SECTION 1-C).



MODERATELY HARD TO HARD	MODERATE TO SLIGHT	5.1 cm (2")				
HARD	SLIGHT	5.1cm - 61cm (2"-2.0')				
MODERATELY HARD	MODERATE TO SLIGHT	0.25 - 5.1cm (1/10"-2")	N 19 E 11 SE N 80 W 15 SE	OPEN, SMOOTH, CURVED. < 10cm - 61cm OPEN, ROUGH, FLAT.	N 75 E 64 SW (S) N 81 W 90 (P)	15m - 61m (50'-200') <61m (<200')
MODERATELY HARD TO VERY HARD	SLIGHT	5.1cm - 61cm (2"-2.0')	N 8-11 E 4-5 NW	OPEN, ROUGH, UNDULATING.	N 9 E 82 SE	305+ m (1000'+)

1517-19 7-22-75

MEASURED STRATIGRAPHIC SECTION NEAR THE CONTACT BETWEEN THE GREEN RIVER AND UINTA FORMATIONS (SECTION 1-B).

FIGURE V-17

The structural relationships within the interior of the Uinta Basin are relatively uncomplicated. Along the north margin of the basin the Eocene rock strata incline steeply and dip southward as much as 35° toward the basinal axis. Along the south and southeast margins of the basin the strata incline slightly more toward the north than the ground surface; dips range from 1° to 8° toward the north or northwest and flatten toward the basin (Bradley 1931; Cashion 1967).

Several prominent northwest-plunging anticlines are around the perimeter of the basin; the most notable of these extend outward from the west side of the Douglas Creek Arch near Bonanza, Utah, along the Colorado-Utah border (Ritzma 1957).

The faults within the basin are minor in terms of density and are essentially vertical, trend northwestward, and exhibit small displacements. A system of northwest-trending and northeast-trending vertical joints run throughout the basin region. Most of these joints are open, smooth, well-defined, straight cracks in the rock; the most numerous and closely spaced joints occur in the thinly-bedded marlstone and siltstone, although some joints do occur in the sandstone beds (Bradley 1931; Cashion and Brown 1956; Cashion 1967). Gilsonite veins fill some of the northwest-trending joints and minor faults in the central and eastern portions of the Uinta Basin. (See "Mineral Resources" section and Figure V-24).

The geologic structure at the site is uniform. The strata generally dip less than 5° (below horizontal) toward the north or northwest and have no known faults. Within the proposed mining zone dip is generally 28 m/km to 47 m/km (150 ft/mi to 200 ft/mi) toward the northwest; the orientation of the strata is shown in Figure V-16.

Minor folds--a result of soft-sediment deformation--are found only in the lower part of the Uinta Formation and in the uppermost part of the Green River Formation; the folds are so small, however, that mapping is not practicable. Measurements of bedding and jointing orientations are shown on Figure V-9. Each symbol represents the orientation of a planar surface--either bedding or jointing.

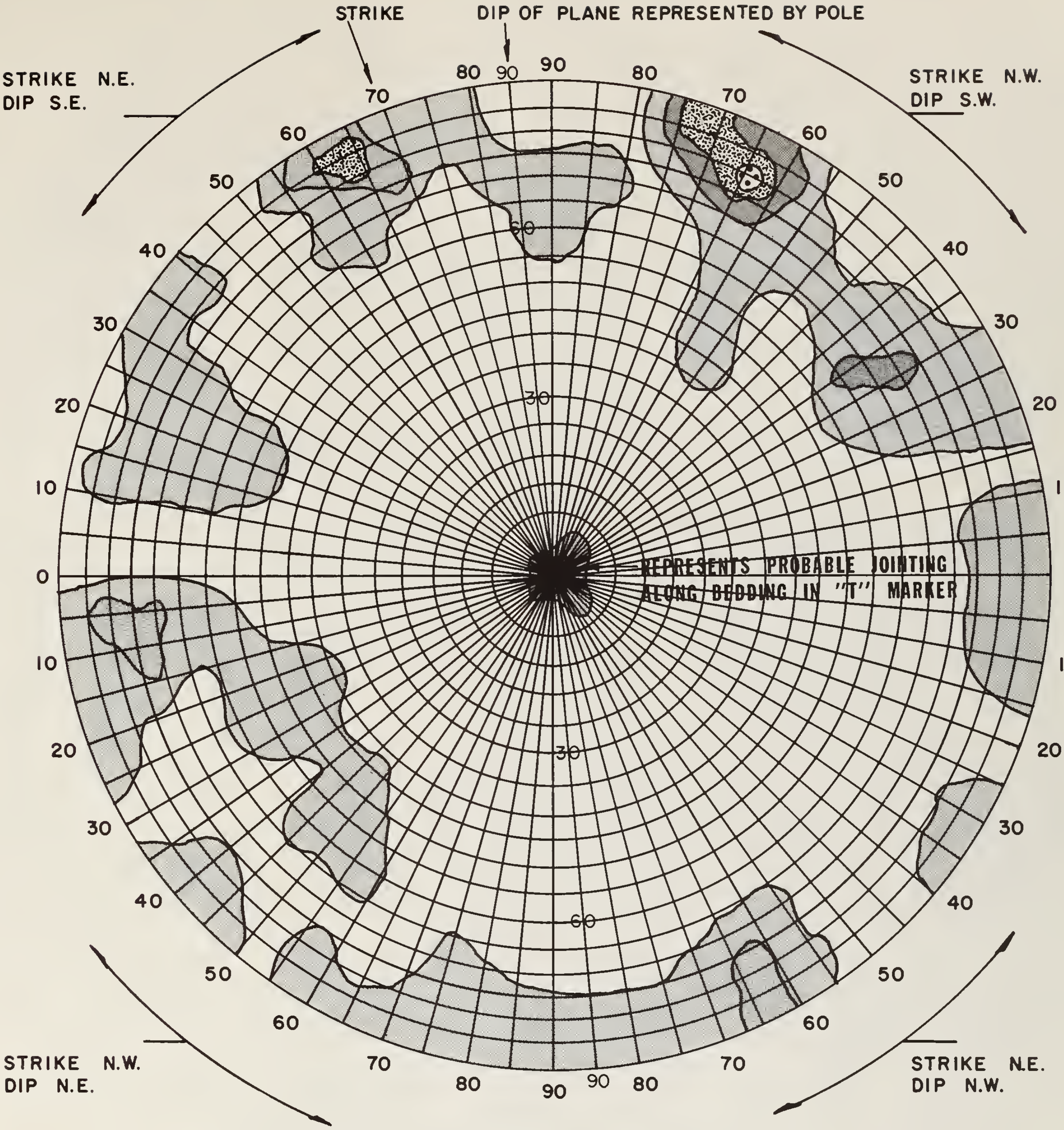
Sets of near-vertical joints (rock fractures) occur throughout the site area. Since the joints are crucial to the overall strength and stability of the strata, they have been mapped and analyzed in detail. In this process each mapped joint orientation was plotted as a point (pole) on a circular grid according to its strike and dip. Then, based on the density of the poles falling within different areas of the grid, the percentage of contour was diagrammed (see Figures V-10, V-18 through V-20). These diagrams show the joint set orientations which are of primary, secondary, and tertiary importance in the mine area. Figure V-10 includes all of Tracts U-a and U-b; Figure V-18 includes the area to the northeast of Tract U-b; Figure V-19 includes the southwest portion of Tract U-b; and Figure V-20 includes the area south of Tract U-a.

Within the site, the primary set of joints trends north 62° west and dips 86° northwest. The three secondary sets trend north 22° east, north 18° east, and north 33° east. These secondary joint sets dip 88° northwest, 88° southeast, and 87° southeast, respectively.

The physical character of the joints in the Uinta Formation is extremely variable. Smooth, large, flat, open joints are the most noticeable; however, there are also numerous small, rough, closed joints throughout the section. Figure V-17 is a detailed stratigraphic description of joint character, spacing, length, and orientation within the most extensively exposed unit. Character of the joints also varies within the Green River Formation, although they are mostly smooth, open, and flat (see Figure V-15).

The stratigraphic section of the Parachute Creek Member was measured in Hells Hole Canyon rather than on the tracts, because of the more exposed and longer outcrops in the canyon. The stratification and jointing characteristics there are probably comparable to the same section of strata that extends beneath the site; however, Cleveland Cliffs Iron Company reported that inclined fractures (joints) were nearly absent in the stratigraphic interval cored and that there were only a very few short, vertical fractures in that zone. Since vertical drill holes will not reflect the actual occurrence frequency of vertical jointing, additional slanted core holes may be drilled in the future. Such studies will be useful in evaluating the stability of the strata within and around the mining zone.

Investigations of rock mechanics to evaluate the physical characteristics of the groundmass immediately above, within, and below, the oil shale zone were conducted to provide design criteria for underground mine development. Tests were run on selected intervals of cores from the X-holes and P-holes. These included deformation tests, uniaxial and triaxial compression tests to destruction, Brazilian tests, and density determinations. The tests were run on the intervals of core shown on Table V-10. The results of these tests were submitted directly to the WRSP and the AOSS by CCIC.



PURPOSE

ANALYSES OF PRINCIPLE JOINT SYSTEMS

AVERAGES

PRIMARY SET ... N69W/80SW
N63E/81SE

SECONDARY SETS ... N63E/83NW
N33W/66SW
N8W/75NE

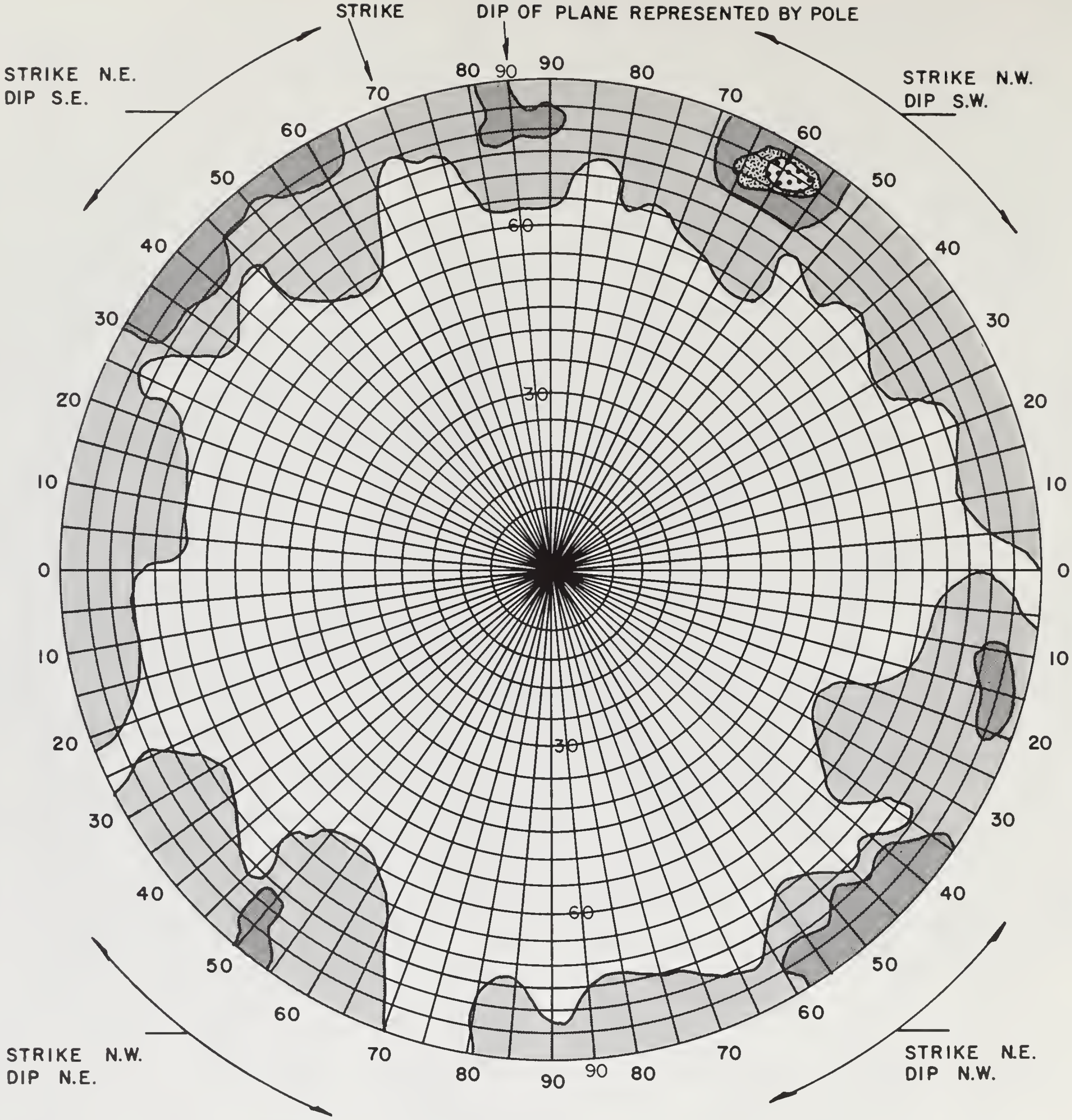
LEGEND

CONTOUR INTERVAL IN PERCENT OF TOTAL SAMPLE

░ 0-5
▒ 5-10
▓ 10-15
⁘ 15-20

COUNT DIAGRAM OF POINTS REPRESENTING JOINT PLANE ORIENTATIONS, SEC. 7,8,17,18, T10S, R24E

FIGURE V-18



PURPOSE

ANALYSES OF PRINCIPLE JOINT SYSTEMS

AVERAGES

PRIMARY SET ... N57W/84SW

SECONDARY SET ... N59E/86SE
N46E/89NW

TERTIARY SET ... N85E/83SE
N17E/85NW
N51W/86NE

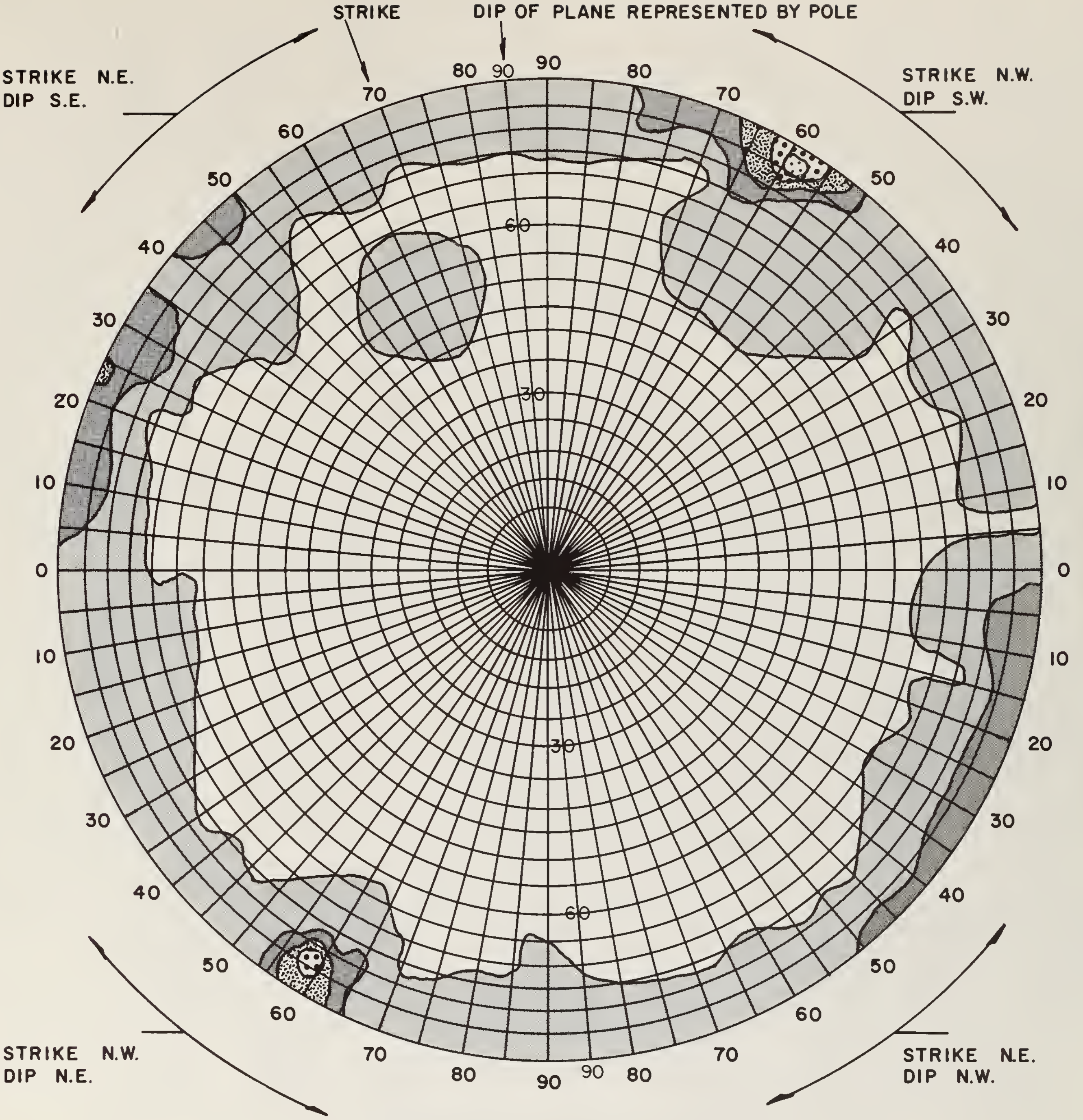
LEGEND

CONTOUR INTERVAL IN PERCENT OF TOTAL SAMPLE

- ░ 0-5
- ▒ 5-10
- ▓ 10-15
- ⁚ 15-20

COUNT DIAGRAM OF POINTS REPRESENTING JOINT PLANE ORIENTATIONS, SEC. 23, 24 & 26, T10S, R25E

FIGURE V-19



PURPOSE

ANALYSES OF PRINCIPLE JOINT SYSTEMS

AVERAGES

PRIMARY SET ... N59W/86SW
N58W/84NE

SECONDARY SET ... N24E/89SE
N24E/89NW

TERTIARY SET ... N45E/88SE

LEGEND

CONTOUR INTERVAL IN PERCENT OF TOTAL SAMPLE

░ 0-5
▒ 5-10
▓ 10-15
▚ 15-20
⁘ 20-25

COUNT DIAGRAM OF POINTS REPRESENTING JOINT PLANE ORIENTATIONS, SEC. 31,32 & 33, T10S, R24E

FIGURE V-20

TABLE V-10

INTERVALS OF CORES ON WHICH ASSAY AND ROCK MECHANICS TESTS WERE PERFORMED

Hole Number
Interval (in feet)*

P-1	P-2	P-3	P-4	X-1	X-2	X-3
676-677	751-752	731-732	672.6 - 673.6	978-979	607-608	438-439
677-678	752-753	732-733	673.6 - 674.6	979-980	608-609	439-440
678-679	753-754	733-734	674.6 - 675.4	980-981	609-610	440-441
685-686	763-764	740-741	680.7 - 681.7	987-988	616-617	441-442
686-687	764-765	741-742	681.7 - 682.7	988-989	617-618	442-443
687-688	765-766	742-743	682.7 - 683.7	989-990	618-619	443-444
697-698	772-773	752-753	692.6 - 693.6	996-997	625-626	450-451
698-699	773-774	753-754	693.6 - 694.6	997-998	626-627	451-452
699-700	774-775	754-755	694.6 - 695.6	998-999	627-628	452-453
706-707	781-782	761-762	701.6 - 702.6	1005-1006	637-638	459-460
707-708	782-783	762-763	702.6 - 703.6	1006-1007	638-639	460-461
708-709	783-784	763-764	703.6 - 704.6	1007-1008	639-640	461-462
715-716	793-794	770-771	710.5 - 711.5	1014-1015	646-647	471-472
716-717	794-795	771-772	711.5 - 712.5	1015-1016	647-648	472-473
717-718	795-796	772-773	712.5 - 713.5	1016-1017	648-649	473-474
727-728	802-803	782-783	722.7 - 723.7	1023-1024	655-656	489-490
728-729	803-804	783-784	723.7 - 724.7	1024-1025	656-657	490-491
729-730	804-805	784-785	724.7 - 725.7	1025-1026	657-658	491-492
736-737	811-812	791-792	731.7 - 732.7	1032-1033	667-668	498-499
737-738	812-813	792-793	732.7 - 733.7	1033-1034	668-669	499-500
738-739	813-814	793-794	733.7 - 734.8	1034-1035	669-670	500-501
745-746	823-824	800-801	740.7 - 741.7	1041-1042	676-677	507-508
746-747	824-825	801-802	741.7 - 742.7	1042-1043	677-678	508-509
747-748	825-826	802-803	742.7 - 743.7	1043-1044	678-679	509-510
757-758	832-833	812-813	752.7 - 753.7	1050-1051	685-686	513-514
758-759	833-834	813-814	753.7 - 754.7	1051-1052	686-687	514-515
759-760	834-835	814-815	754.7 - 755.7	1052-1053	687-688	515-516
766-767	841-842	821-822	761.7 - 762.7	1059-1060	691-692	522-523
767-768	842-843	822-823	762.7 - 763.7	1060-1061	692-693	523-524
768-769	843-844	823-824	763.7 - 764.7	1061-1062	693-694	524-525
775-776	853-854	830-831				
776-777	854-855	831-832				
777-778	855-856	832-833				
787-788	862-863	842-843				
788-789	863-864	843-844				
789-790	864-865	844-845				
796-797	871-872	851-852				
797-798	872-873	852-853				
798-799	873-874	853-854				
805-806	883-884	860-861				
806-807	884-885	861-862				
807-808	885-886	862-863				
817-818						
818-819						
819-820						

TABLE V-10 (Cont.)

Hole Number
Interval (in feet)*

X-4	X-5	X-6	X-9	X-10	X-11
810-811	789-790	651-652	933-934	942-943	835-836
811-812	790-791	652-653	934-935	943-944	836-837
812-813	791-792	653-654	935-936	944-945	837-838
819-820	798-799	663-664	942-943	954-955	847-848
820-821	799-800	664-665	943-944	955-956	848-849
821-822	800-801	665-666	944-945	956-957	849-850
831-832	807-808	672-673	951-952	963-964	856-857
832-833	808-809	673-674	952-953	964-965	857-858
833-834	809-810	674-675	953-954	965-966	858-859
840-841	819-820	681-682	963-964	972-973	865-866
841-842	820-821	682-683	964-965	973-974	866-867
842-843	821-822	683-684	965-966	974-975	867-868
849-850	828-829	690-691	972-973	981-982	877-878
850-851	829-830	691-692	973-974	982-983	878-879
851-852	830-831	692-693	974-975	983-984	879-880
861-862	837-838	702-703	981-982	993-994	886-887
862-863	838-839	703-704	982-983	994-995	887-888
863-864	839-840	704-705	983-984	995-996	888-889
870-871	846-847	711-712	993-994	1002-1003	895-896
871-872	847-848	712-713	994-995	1003-1004	896-897
872-873	848-849	713-714	995-996	1004-1005	897-898
879-880	855-856	720-721	1002-1003	1011-1012	907-908
880-881	856-857	721-722	1003-1004	1012-1013	908-909
881-882	857-858	722-723	1004-1005	1013-1014	909-910
891-892	864-865	732-734	1011-1012	1023-1024	916-917
892-893	865-866	734-735	1012-1013	1024-1025	917-918
893-894	866-867	741-742	1031-1014	1025-1026	918-919
900-901	873-874	742-743	1023-1024	1032-1033	925-926
901-902	874-875	743-744	1024-1025	1033-1034	926-927
902-903	875-876		1025-1026	1034-1035	927-928

*To convert to meters multiply by 0.305

e. Geologic Hazards

Seismicity

Seismic risk is the probability of earthquake damage from ground shaking, subsidence, differential settlement, ground cracking, or liquefaction. Three zones of seismic risk, based on past earthquakes, are identified in Figure V-21. Tracts U-a and U-b are within the lowest-risk zone, where through 1970 six earthquakes have been reported within 100 mi of the site. Ground shaking associated with four of these events reached intensity V, on the Modified Mercalli Intensity Scale of 1931. Since the other two events were of relatively minor intensity, they are not shown on the figure. Descriptions by Coffman and Van Hake (1973) of the four intensity V earthquakes are as follows:

> 1950. January 17. Near Soldier Summit, Utah. Strongest at Grand Junction, Colo., where plaster cracked. Building cracked at Green River.
>
> 1961. May 6. East-central Utah. Slight damage to brick at Columbia. Also felt at Sunnyside.
>
> 1966. February 14. Rangely, Colo. Frightened all in community.
>
> 1970. April 21. Rangely, Colo. Small objects shifted and overturned at the Texas Oil Camp. An aftershock was felt about 6 hours later.

Surface Faulting

No active surface faults have been reported in the vicinity of the tracts.

Landslides and Rockfalls

Ancient landslides are evident along many of the steep cutbanks of the White River. In addition, there are examples of recent debris flows within steep drainages and rockfalls along steep ridges on the tracts. Areas particularly susceptible to rockfalls are indicated with dark-gray or black on Figure V-8.

Severe thunderstorms and accompanying flash floods are the primary force initiating landslides and debris flows in this area. Rockfalls occur occasionally, probably without warning.

Subsidence

A precise releveling survey was recently completed for the WRSP to determine whether or not subsidence or emergence of the ground surface is occurring in the vicinity of the tracts. Benchmarks used in the survey were originally established by the U. S. Coast and Geodetic Survey in 1933 and 1934; therefore, the time interval of record includes the past 42 years. Overall accuracy of the releveling program was within first-order limits.

The survey route shown on Figure V-22, was 18.0 km (28.9 mi) long and included 16 benchmarks. Elevations of each benchmark and the relative profile of the entire route are shown on Figure V-23.

Elevation differences determined by the survey showed no meaningful trends that would indicate possible subsidence during the past half century. If there is presently any movement of the ground surface, the movement is at such a slow rate that it would be impossible to detect using current survey methods.

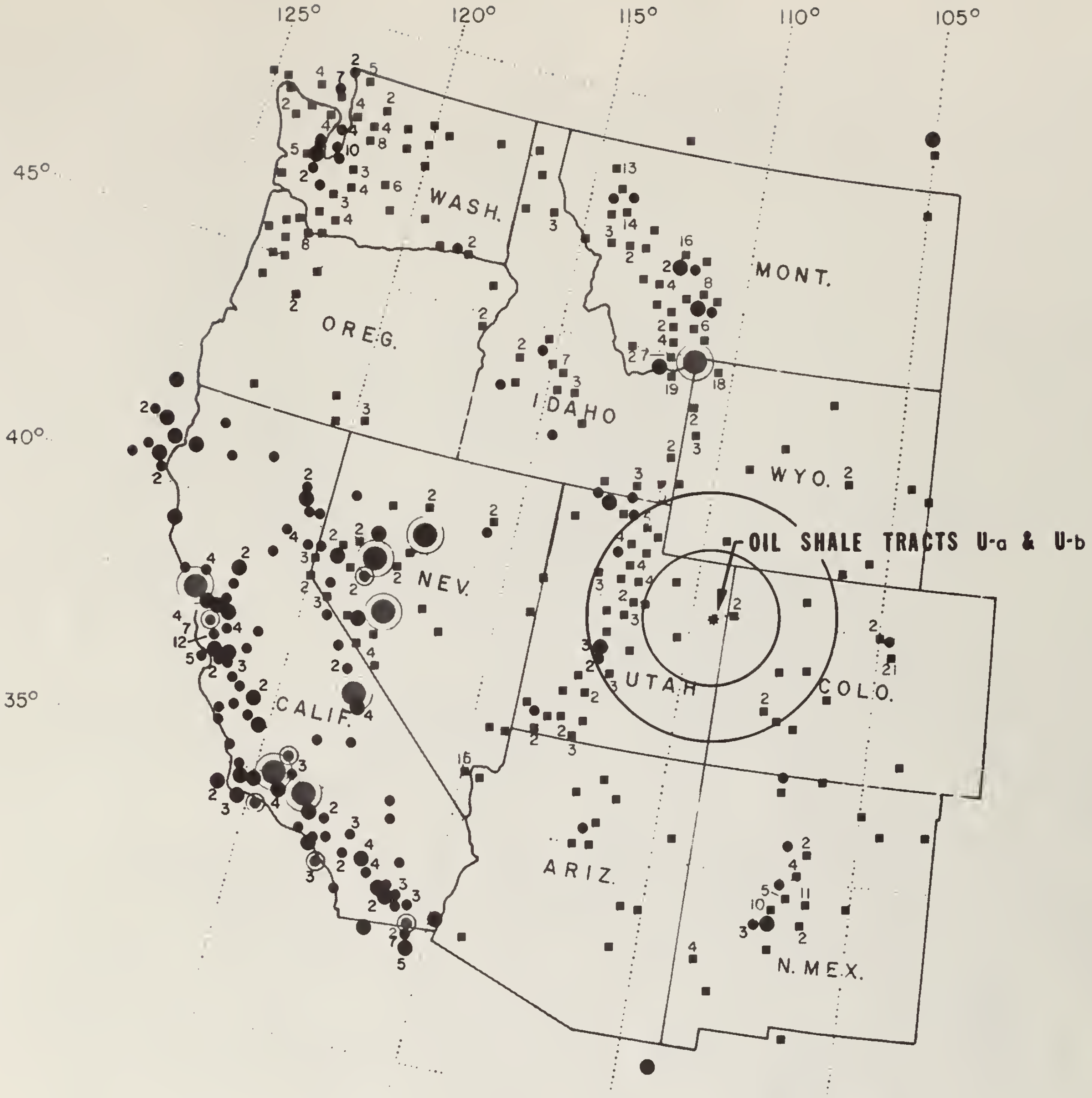
f. Mineral Resources

Economically important deposits of minerals within the Uinta Basin are shown on Figure V-24.

Hydrocarbons

The lake deposits of Eocene age within the Uinta Basin contain large amounts of organic matter derived from shallow-water microorganisms and wind-blown pollen and spores which have formed a large number of hydrocarbon deposits of oil and gas, oil shale, gilsonite, and bituminous sandstones. The coal deposits of Cretaceous age formed from plant remains that accumulated prior to the development of the Uinta Basin.

Oil Shale: Oil shale is not shale at all; it is actually a dense, tough, thinly-bedded, dark-to-olive-brown to brownish-black marlstone. The organic fraction of oil shale is derived



LEGEND

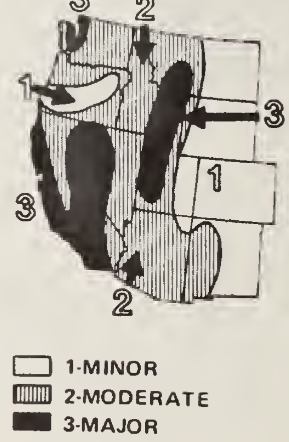
- ▪ —— INTENSITY V-VII (except California)
- • —— INTENSITY VII-VIII
- ● —— INTENSITY VIII-IX
- ◉ —— INTENSITY IX-X
- ◉ —— INTENSITY X-XII

200 MILE RADIUS

100 MILE RADIUS

✱ SITE

SOURCE: Earthquake History of the United States, National Oceanic and Atmospheric Administration Environmental Data Service, ed. by Coffman and Von Hake, 1973



vtn

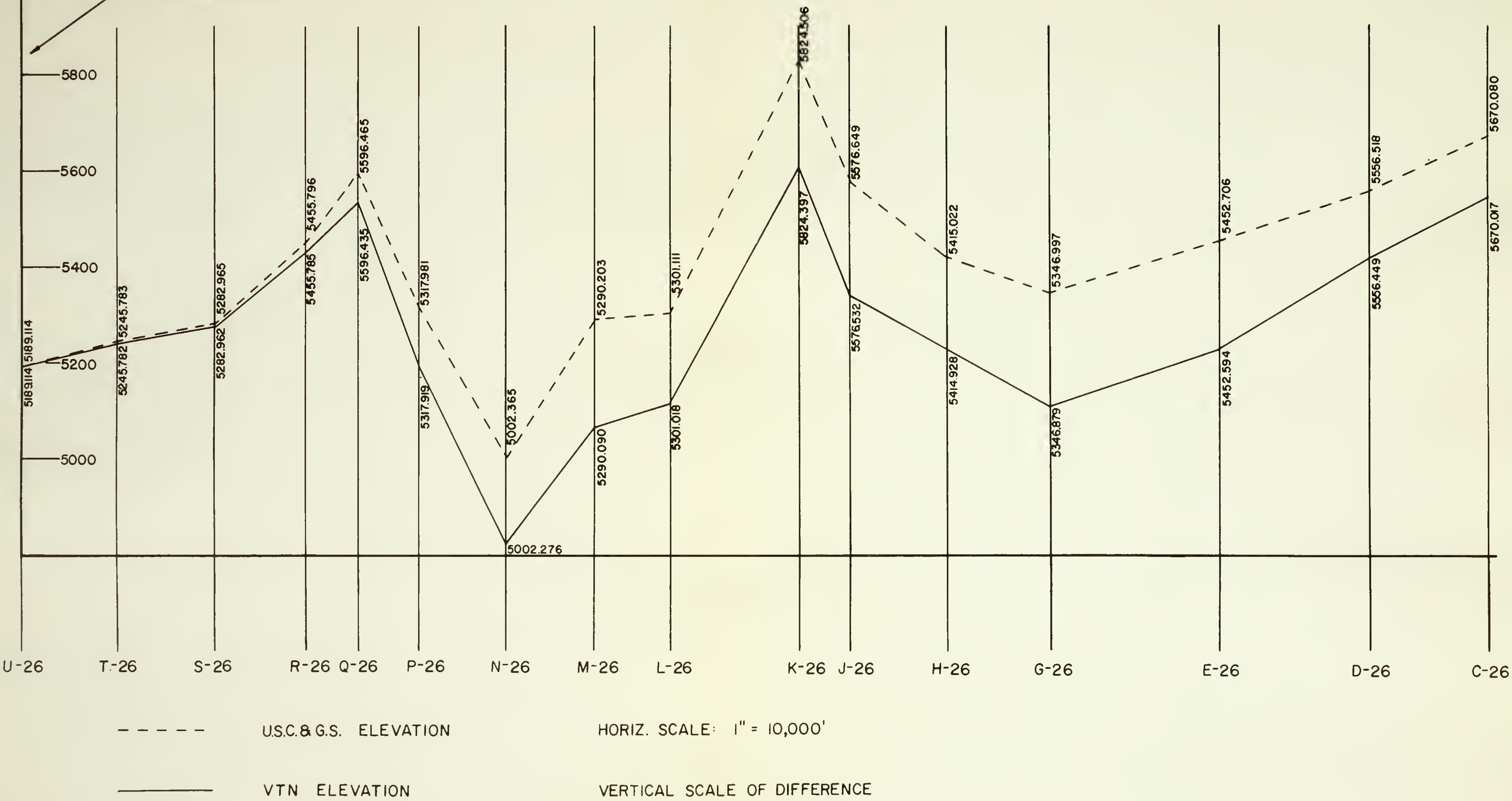
EARTHQUAKES THROUGH 1970 AND SEISMIC RISK MAP FOR WESTERN UNITED STATES

FIGURE V-21

PRECISE RELEVELING FOR SUBSIDENCE INVESTIGATION

FIGURE V-22

NOTE: THIS SCALE PERTAINS ONLY TO THE U.S.C.& G.S. ELEVATIONS. ELEVATION DIFFERENCES DETERMINED BY VTN ARE SHOWN ON AN EXAGGERATED VERTICAL SCALE OF 1" = 0.100'

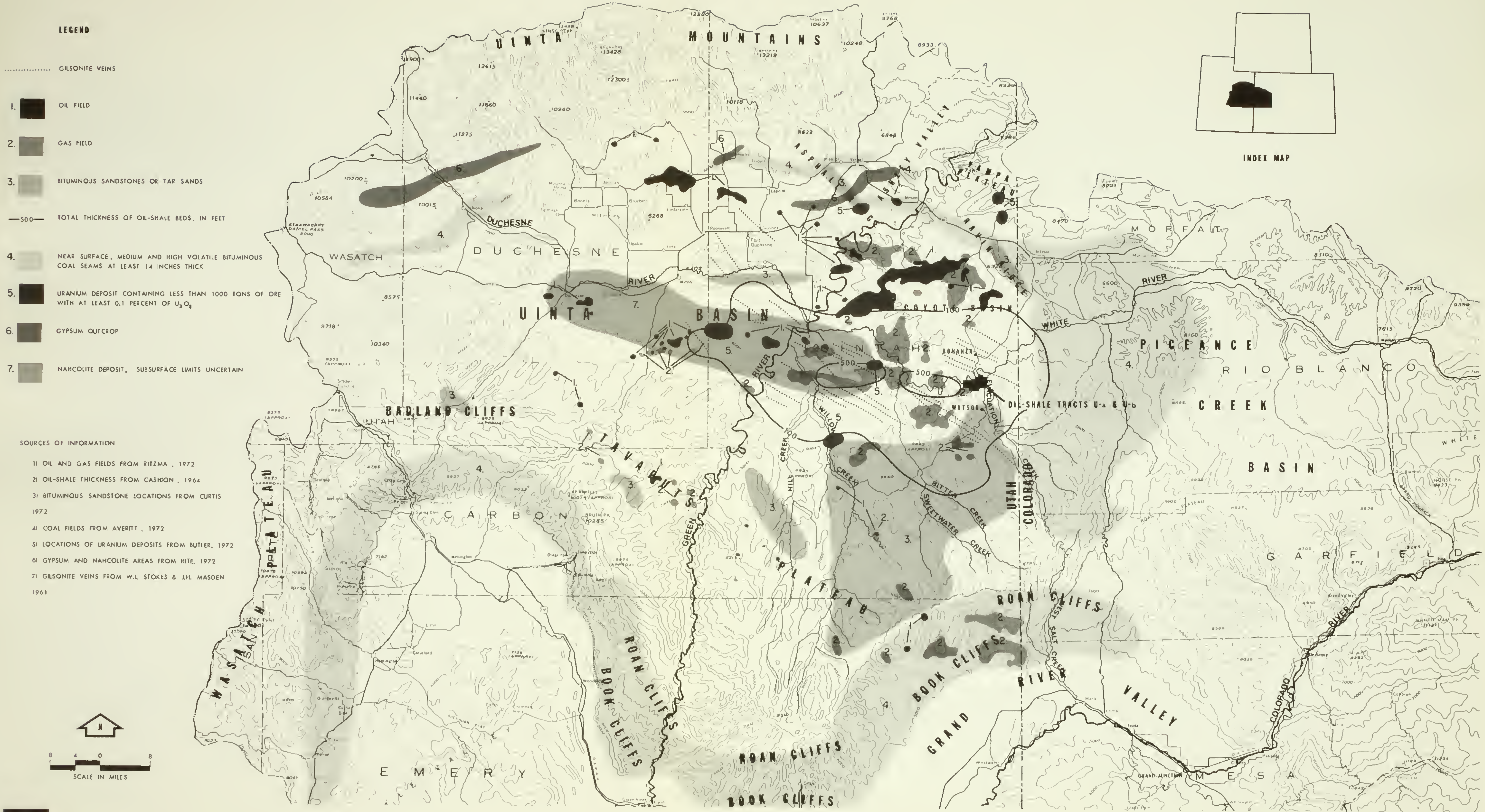


HORIZ. SCALE: 1" = 10,000'

VERTICAL SCALE OF DIFFERENCE
BETWEEN U.S.C.& G.S. AND VTN
ELEVATIONS: 1" = 0.100'

PRECISE RELEVELING PROFILE

FIGURE V-23



MINERAL RESOURCES OF THE UINTA BASIN

FIGURE V-24

LEGEND
GILSONITE VEINS
1. OIL FIELD
2. GAS FIELD
3. BITUMINOUS SANDSTONES OR TAR SANDS
—500— TOTAL THICKNESS OF OIL-SHALE BEDS, IN FEET
4. NEAR SURFACE, MEDIUM AND HIGH VOLATILE BITUMINOUS COAL SEAMS AT LEAST 14 INCHES THICK
5. URANIUM DEPOSIT CONTAINING LESS THAN 1000 TONS OF ORE WITH AT LEAST 0.1 PERCENT OF U3O8
6. GYPSUM OUTCROP
7. NAHCOLITE DEPOSIT, SUBSURFACE LIMITS UNCERTAIN
SOURCES OF INFORMATION
1) OIL AND GAS FIELDS FROM RITZMA, 1972
2) OIL-SHALE THICKNESS FROM CASHION, 1964
3) BITUMINOUS SANDSTONE LOCATIONS FROM CURTIS 1972
4) COAL FIELDS FROM AVERITT, 1972
5) LOCATIONS OF URANIUM DEPOSITS FROM BUTLER, 1972
6) GYPSUM AND NAHCOLITE AREAS FROM HITE, 1972
7) GILSONITE VEINS FROM W.L. STOKES & J.H. MASDEN 1961
INDEX MAP
N
8 4 0 8
SCALE IN MILES
UINTA MOUNTAINS
WASATCH
DUCHESNE
DUCHESNE RIVER
UINTA BASIN
ASPHALT RIDGE
ASHLEY VALLEY
YAMPA PLATEAU
RAVEN RIDGE
MOFFAT
WHITE RIVER
COYOTE BASIN
UINTAH
BONANZA
WATSON
OIL-SHALE TRACTS U-a & U-b
EVACUATION CREEK
PICEANCE CREEK BASIN
RIO BLANCO
WHITE
BADLAND CLIFFS
UTAH
TAVAPUTS PLATEAU
CARBON
WASATCH PLATEAU
GREEN RIVER
WILLOW CREEK
HILL CREEK
BITTER CREEK
SWEETWATER CREEK
UTAH
COLORADO
GARFIELD
ROAN CLIFFS
BOOK CLIFFS
WEST SALT CREEK
GRAND RIVER VALLEY
COLORADO RIVER
GRAND JUNCTION
MESA
EMERY

from decaying microorganisms that originally fluorished in shallow tropical lakes and from pollen, spores, and fragments of land plants blown into the ancient lake system. The inorganic fraction of the oil shale is composed mainly of dolomite and calcite with minor amounts of quartz, feldspars, analcime, clay, and pyrite (Bradley 1970). These kerogen-rich deposits occur primarily within the Parachute Creek Member of the Green River Formation.

Cashion (1967) defined oil shale as marlstone that will yield at least 0.063 liters of oil per kg (15 gal/ton). Based on mining and processing technology at that time, he estimated that the oil shale most suitable for eventual mining is that which will produce from 0.104 liters to 0.1381 liters or more per kg (25 gal/ton to 33 gal/ton) and which occurs in zones a minimum of 8 m (25 ft) thick.

The major oil shale beds in the southeast portion of the basin are approximately 152 m to 213 m (500 ft to 700 ft) thick in two areas: one is along the White River about 24 km (15 mi) west of the Utah-Colorado border in the vicinity of the tracts, and the other area is about 32 km (20 mi) west of the tracts.

Most of the area within the Uinta Basin south of a line between Duchesne and Leota, Utah, is underlain by oil shale 4.6 m (15 ft) thick or more. Cashion (1967) estimates the acreage, thickness, and potential oil yield of oil shale deposits in Tracts U-a and U-b to be 850 million barrels. This value was derived using Cashion's estimated average thickness of oil shale in T10S. R.24E. of 97.5 m (320 ft) that will yield an average of 0.063 l/kg (15 gal/ton) multiplied by the area within the oil shale tracts. The actual volume of oil shale proposed to be mined is much less; the potential mining zone has been estimated by Cleveland Cliffs Iron Company (CCIC) to be about 30.5 m (100 ft) thick. The results of the Fisher assays being prepared by CCIC (see Table V-10) will enable the WRSP to more accurately estimate the amount of oil available. The location of the roof and the floor of the mining zone is tentative. The CCIC has estimated that the roof will be on a natural parting plane 6 m to 8 m (20 ft to 25 ft) above the mahogany marker and that the floor will be on a parting plane 11 m to 12 m (35 ft to 40 ft) below the marker. Table V-11 gives the approximate depths of the roof and the floor in the X-holes and P-holes.

The lithologic logs (included with hydrogeologic logs given to the WRSP) show that the mining zone is laterally extensive throughout the tracts and that it does not thin appreciably in any direction.

TABLE V-11

APPROXIMATE DEPTHS OF THE ROOF AND FLOOR OF THE MINING ZONE WITHIN THE BOREHOLES

Hole Number	Roof	Floor
P-1	218 m (715 ft)	238 m (780 ft)
P-2	242 m (794 ft)	262 m (859 ft)
P-3	235 m (771 ft)	255 m (836 ft)
P-4	207 m (678 ft)	226 m (743 ft)
X-1	298 m (978 ft)	318 m (1043 ft)
X-2	188 m (616 ft)	208 m (681 ft)
X-3	136 m (445 ft)	155 m (510 ft)
X-4	247 m (812 ft)	267 m (877 ft)
X-5	240 m (787 ft)	260 m (852 ft)
X-6	200 m (657 ft)	220 m (722 ft)
X-9	280 m (919 ft)	300 m (984 ft)
X-10	289 m (947 ft)	308 m (1012 ft)
X-11	256 m (841 ft)	276 m (906 ft)

Oil and Natural Gas: Wells that penetrate structural and stratigraphic traps in sandstone strata within the Green River Formation produce the majority of oil and gas throughout the Uinta Basin, although there are some accumulations within the Uinta Formation and in the middle of the Wasatch Formation. The boundaries of the oil and gas fields in relation to the tracts are defined in Figure V-24. Refer to Ritzma (1972) for estimates of the original hydrocarbons within each field and total production from each field through 1968.

Borehole geophysical logs from oil and gas test wells were collected within 8 km (5 mi) of the tract boundary (well locations are shown on Figure V-3; geophysical logs are tabulated in Table II-15 in Section II.C.b, Ground Water). Eight holes have been drilled so far for oil and gas exploration on the tracts. Only one--in the central portion of Tract U-a within Southam Canyon--produced economically valuable amounts of oil and gas; the other holes were dry. In the site vicinity a group of about 14 productive gas wells are centered approximately 6.4 km to 8.0 km (4 mi to 5 mi) southwest of Tract U-a. Another three productive gas wells are 2.4 km to 4.8 km (1.5 mi to 3 mi) northwest of Tract U-a. Although these wells penetrate the entire Eocene strata, the principal productive zone, the Mesa Verde Formation of Cretaceous age, lies considerably deeper in the section.

Gilsonite: Classed as an asphaltite, gilsonite is a black, tar-like, brittle substance that has formed as a residue of natural petroleum. Homogeneous veins of gilsonite occur along straight and continuous northwest-trending joints and minor faults in the east-central Uinta Basin, primarily within the Uinta Formation. These veins probably originated as petroleum that oozed upward from permeable sandstone reservoir rocks along vertical, open fissures extending into the overlying rocks. Cashion (1964) estimated the original gilsonite reserve of the basin to be about 408 x 10^8 kg (45 million tons), about one-tenth of which had been mined out by that time. As shown on Figure V-24, there are no gilsonite veins exposed at the surface within Tracts U-a and U-b. Although a small vein (2-4 cm) was mapped by Cashion 1974, these have not been observed in the field during the course of baseline data collection program.

Bituminous Sandstones: Sandstones impregnated with asphalt-like bituminous material occur in surface exposures along the southwestern, southern, and southeastern margins of the Uinta Basin and along the Asphalt and Raven Ridges in the northeast part of the basin. These tar sands are found in the Green River, Uinta, and Duchesne River formations; and probably accumulated from oil seeping upward from the

Green River Formation sometime after the deposition of the Duchesne River Formation (Covington 1957; Curtis 1972). The total reserves have not been estimated because of the lack of subsurface control and the highly variable nature of the asphalt impregnation (Cashion 1967), but tabulation of detailed descriptive data for each of these occurrences within the Uinta Basin have been presented by Curtis (1972). No bituminous sandstone has been found within Tracts U-a and U-b.

Coal: Extensive deposits of medium-volatile and high-volatile bituminous coal seams with commercial value occur near the surface along the southern margin of the Uinta Basin in the Castlegate and Book Cliffs Field; in the Vernal Field along the northeast margin of the basin; and in a relatively small area known as the Blacktail Field in the northwest corner of the basin. The rest of the Uinta Basin interior is probably underlain by a similar grade of coal, but these seams are at depths ranging from 100 m to 300 m (300 ft to 1,000 ft) underground (Averitt 1972). There is no coal in the vicinity of the tracts.

These coal beds were formed during the Cretaceous Period, when a swampy marsh environment existed along the shores of a vast marine seeway. The environment was favorable for rapid accumulation of partially decayed plant material that eventually metamorphosed into coal.

Uranium

Minor uranium deposits have been found at seven different locations within the Uinta Basin. Three groups of deposits occur in Tertiary-aged sedimentary deposits in the central portion of the basin, and three groups of older uranium deposits occur within Mesozoic-aged rocks deep in the subsurface in the northeast portion of the basin. Each of these uranium deposits is relatively small and has been estimated to hold less than 907 x 10^3 kg (1,000 tons) of ore containing at least 0.1 percent of U_3O_8 (Butler 1972). There are no uranium deposits known to occur in the vicinity of the tracts.

Gypsum

Gypsum is a hydrous calcium sulfate that can be industrially processed into a semi-hydrated form used extensively in the manufacture of building materials. Two narrow east-west trending outcrops of gypsum lie along the axis of the Uinta

Basin; one in the eastern part, and the other across the western part of the basin (Hite 1972). These reserves are derived from weathered anhydrite beds deposited as evaporites during the Late Eocene Period while ancient Lake Uinta was in the final stages of drying up. No gypsum deposits occur in the site area.

Nahcolite

Nahcolite, a potential source of soda ash, is a sodium-bicarbonate mineral occurring within the upper part of the Green River Formation in the subsurface of the central Uinta Basin. Hite (1972) estimates that as much as 648 km^2 (250 mi^2) of land between Ouray and Duchesne, Utah, may be underlain by a nahcolite zone of up to 6.1 m (20 ft) thick. Within the tracts are many nahcolite nodules associated with the bird's nest zone; however, most of the nahcolite has already been dissolved by ground water percolation.

Occurrences of nahcolite noted in the drill hole lithologic logs were analyzed for sodium bicarbonate content. The results of X-ray defraction analyses for nahcolite for selected core intervals are shown in Table V-12.

Nahcolite was found in only five core intervals within the mining zone. These intervals have a total thickness of 1.44 m (4.72 ft) and an average concentration of about 35 percent. The CCIC concluded that nahcolite was present in only a few small, scattered cavities within the mining zone and would not be economical to extract.

Extractable Alumina

Assayed shale from the X-holes and P-holes was analyzed to determine whether alumina (dowsonite) could be extracted economically. Alumina concentration within and adjacent to the mining zone (15 m above and below the mahogany marker) was found to range from 0.054 percent to 1.420 percent. The results of the analyses are shown in Appendix V-4. The CCIC concluded that these concentrations were low and that it would not be economical to extract alumina from the processed shale.

4. CONCLUSIONS

The geologic investigations performed to date for the White River Shale Project satisfy the Federal Lease Stipulations

TABLE V-12

NAHCOLITE CONTENT IN SELECTED CORE INTERVALS

Hole No. and Interval		% Nahcolite
P-2	126.70 - 256.90 m (842.20 - 842.85 ft)	31%
X-11	255.12 - 255.19 m (837.00 - 837.25 ft)	-0-
X-4	260.39 - 260.60 m (854.30 - 855.00 ft)	45%
X-4	260.21 - 260.33 m (853.70 - 854.10 ft)	35%
X-4	259.90 - 260.15 m (852.68 - 853.50 ft)	17%
X-1	327.20 - 327.28 m (1073.50 - 1073.75 ft)	-0-
X-2	201.63 - 202.31 m (661.50 - 663.75 ft)	38%

and Conditions of Approval, provide geotechnical information for satisfactorily locating mine shafts and facilities, and define the present geological conditions on the tracts.

5. WORK SCHEDULED

There are no future geological investigations scheduled for the WRSP environmental baseline program. The geologic trace metal analysis results will be reported in future Quarterly Baseline Reports.

Five additional holes are scheduled to be drilled during the summer. Three vertical holes are designed to core the mining zone to gain additional resource information, and two slant (30^o) holes are designed to obtain fracture data and additional resource information.

GLOSSARY

Alkali soil: a soil with so high a degree of alkalinity (pH 8.5 or higher) or so high a percentage of exchangeable sodium (15 percent or more of total exchangeable bases), or both, that growth of most crop plants is severely restricted.

Alluvial fan: a low, outspread, relatively flat to gently sloping mass of loose rock material shaped like an open fan and deposited by a stream at the place where it emerges from a narrow, steep valley on to a plain or broad valley.

Alluvium: unconsolidated sediments deposited during comparatively recent geologic time by a stream or other body of running water.

Analcime: a hydrous sodium aluminum silicate mineral. It is white or slightly colored.

Anhydrite: gypsum (calcium sulfate) without its water of crystallization.

Aquic: a reducing soil regime. Some soil horizons of an aquic soil are saturated at times with water while dissolved oxygen is present.

Arch: a broad, regional scale upfold of strata.

Aridisols: soils that are generally dry and have light-colored or thin surface horizons with well-expressed lime horizons (calcic horizon) or sodic horizons (natic horizon).

Asphaltite: a group of naturally occurring, black solid hydrocarbon minerals.

Available water holding capacity: the capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field capacity and the amount at wilting point. It is commonly expressed in inches of water per inch of soil.

Calcareous soil: a soil that contains calcium carbonate or lime. The following terms are used to describe calcareous soils and the amounts of calcium carbonate equivalent the soil contains: slightly calcareous - 1 to 3 percent calcium carbonate equivalent. moderately calcareous - 3 to 15 percent calcium carbonate equivalent. strongly calcareous - 15 to 40 percent calcium carbonate equivalent.

Calciorthids: orthids that have had much lime in the parent materials or added in dust. The low rainfall is unable to remove the lime completely from the surface soil. The only horizons normally present are the ochric surface and a calcic horizon whose upper boundary generally is at a depth of less than 50 cm (20 inches).

Channery soil: a soil containing 15 to 20 percent thin, flat sandstone, siltstone, limestone or shale fragments up to 6 inches along the longer axis. A very channery soil is one that contains more than 50 percent channery fragments.

Colluvium: a loose, heterogeneous mass of soil material or rock fragments deposited chiefly by mass wasting, at the base of a steep slope.

Color, soil: according to the Munsell Notation System, determined by degrees of three variables--hue, value, and chroma. For example, a notation of 10YR6/4 is a color with a hue of 10YR, a value of 6, and a chroma of 4. The color name is light yellowish brown.

Conglomerate: a coarse-grained sedimentary rock of rounded fragments larger than 2 mm in diameter set in a fine-grained matrix of sand, silt or any of the common material cementing materials. The coarse grains are fragments of pre-existing rocks.

Cretaceous Period: the final period of the Mesozoic Era. It is thought to have covered the span of time between 136 and 65 million years ago.

Cuesta: a symmetrical ridge with a long gentle slope corresponding to the dip of a resistant bed and a steep slope on the cut edge of the beds.

Debris flow: a mass movement involving rapid flowage of debris, especially a high-density mudflow resulting from heavy rain.

Dendritic drainage pattern: a drainage pattern in which the streams branch irregularly in all directions and at almost any angle resembling the branching of veins in a maple leaf.

Dolomite: a common rock forming mineral composed of calcium magnesium carbonate.

Entisols; soils that lack distinct horizons.

Eocene Epoch; an early epoch of the Tertiary Period of the Cenozoic Era. It is thought to have covered the span of time between 58 and 36 million years ago.

Ephemeral stream: a stream or portion of a stream that flows briefly only in direct response to precipitation in the immediate area.

Evaporite mineral: a mineral such as halite (rock salt) which has formed as a result of evaporation.

Fault: a surface or zone of rock fracture along which there has been displacement.

First-order limits: maximum allowable discrepancy for high precision elevation determinations.

Flaggy soil: contains relatively thin fragments (6 to 15 inches long) of sandstone, limestone, slate or shale. A single piece is a flagstone.

Fluvents: mostly brownish soils that formed in recent water-deposited sediments, mainly on flood plains, fans and deltas.

Fluvial: of or pertaining to rivers or streams.

Formation: the basic rock-stratigraphic unit in the local classification of rocks consisting of a body of rock generally characterized by some degree of internal homogeneity or distinction features.

Friable: crumbles in the hand.

Frigid: having a mean annual soil temperature of less than 8°C (47°F).

Geomorphology: the study of the origin and development of landforms.

Hogback: a sharp-crested ridge formed by differential erosion of a resistant bed of steeply dipping rocks.

Horizon, soil: a layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes.
O horizon - the layer of organic matter on the surface of some mineral soils. This layer consists of decaying plant residues.
A horizon - the mineral horizon at the surface or just below an O horizon. This horizon is the one in which living organisms are most active and, therefore, is marked by the accumulation of humus. The horizon may have lost soluble salts, clay and/or sesquioxides.

Hydrate: a mineral compound in which water is part of the chemical composition.

Infiltration: the inflow of water into earth materials.

Interfluve: the area between streams, especially the upland between adjacent stream valleys.

Joint: a fracture in a rock. A joint differs from a fault in lacking displacements on opposite sides of the fracture.

Kerogen: A mineraloid consisting chiefly of low forms of plant life such as algae, pollen and spores.

Lacustrine: pertaining to, produced by, or formed in a lake.

Limestone: a sedimentary rock consisting chiefly of calcium carbonate, primarily in the form of the mineral calcite.

Liquid limit: the moisture content at which a soil passes from a plastic to a liquid state.

Lithic: a lithic contact is a boundary between soil and continuous, coherent underlying material (sandstone and shale bedrock). A lithic soil is diagnostic at the subgroup level if it is within 50 cm (20 inches) of the surface of the mineral soil.

Lithologic: of or pertaining to rocks.

Loamy-skeletal: rock fragments make up 35 percent or more of the soil by volume, enough fine earth to fill interstices larger than 1 mm; the fraction finer than 2 mm is loamy as defined for the loamy particle-size class.

Mahogany zone: a descriptive name for the zone of commercially important oil shale.

Marlstone: a rock consisting of approximately equal amounts of carbonate and clay.

Mass wasting: the downslope movement of rock debris under the influence of gravity.

Metamorphose: to subject solid rocks to physical and chemical changes at depth in the Earth's crust as a result of changes in temperature, pressure, and chemical environment.

Mixed: the soil has less than 40 percent of any one mineral other than quartz or feldspars.

Morphogenetic region: a region in which a given set of climatic conditions and predominant geomorphic processes give the landscape certain regional characteristics which contrast with those developed under different climatic conditions.

Mottling soil: irregularly marked with spots of different colors that vary in number and size. Mottling in soils usually indicates poor aeration and lack of drainage.

Nahcolite: a white hydrocarbon mineral containing sodium.

Natrargids: argids that have a natric horizon. The natric horizon is a special kind of argillic horizon that has 15 percent or more saturation with exchangeable sodium in some horizon within 40 cm (16 inches) of the surface.

Nutrients: chemical elements, ions, or compounds necessary for biological growth.

Oil shale: a marlstone which is rich in kerogen (distillable hydrocarbons).

Paleocene Epoch: the earliest epoch of the Tertiary Period of the Cenozoic Era. It is thought to have covered the span of time between 65 and 58 million years ago.

Pedon, soil: a volume of soil, one meter on each side and two meters deep, or to rock or other inhibitory layers.

Percolation: the movement of water through the earth.

Permeability, soil: that quality of the soil that enables it to transmit water or air. Some of the terms used to describe permeability are as follows: Slow - 0.06 to 0.2 inches per hour. Moderate - 0.60 to 2.0 inches per hour. Rapid - 6.0 to 10.0 inches per hour.

pH value: a numerical means for designating acidity and alkalinity in soils. A pH value of 7.0 indicates precise neutrality, a higher value, alkalinity, a lower value, acidity. Degrees of acidity or alkalinity are: medium acid--5.6 to 6.0 pH; slightly acid--6.1 to 6.5 pH; neutral--6.6 to 7.3 pH; mildly alkaline--7.4 to 7.8 pH; moderately alkaline--7.9 to 8.4 pH; and strongly alkaline--8.5 to 9.0 pH.

Physiography: the descriptive study of landforms.

Plastic limit: the moisture content at which a soil changes from a semisolid to a plastic state.

Platy structure: soil structure in the form of thin flat sheets of soil.

Pluvial erosion: erosion resulting from the action or effects of rain.

Quaternary Period: the second period of the Cenozoic Era. It is thought to have covered the last two or three million years.

Saline soil: contains soluble salts in amounts that impair growth of plants.

Soil families: classification based on properties important to the growth of plants or to engineering.

Strata: layers or bodies of homogeneous or gradational sedimentary material of any thickness visually separable from each other by distinct changes in sedimentary material.

Stratigraphic: of or pertaining to the sequence of rock strata of the Earth's crust.

Stromatolite: a variously shaped (often domal), laminated, sedimentary structure primarily composed of calcium and formed in a shallow-water environment. It is formed under the influence of blue-green algae that traps fine material and precipitates calcium carbonate, developing a structureless colony.

Structure, soil: the arrangement of primary soil particles into compound particles that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil properties. The principle forms of soil structure are: platy (laminated), prismatic (vertical axis of aggregates larger than horizontal), columnar (prism with rounded tips), blocky (angular or subangular), or granular. Structureless soils are single grain or massive.

Texture, soil: the relative proportions of sand, silt and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay and clay. The sand, loamy sand and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Torrifluvents: fluvents of arid climates that are not flooded frequently or for long periods. They have a torric moisture regime (soils are hot and dry during the summer).

Torriorthent: soils with a torric moisture regime that have more than 35 percent rock fragments (by volume) in some subhorizon above the lithic contact.

Typic: an adjective used for the subgroup that is thought to typify the great group. For example, the Torrifluvents that typify the central concept of the great group are called Typic Torrifluvents.

Ustic: a soil of limited moisture, but the moisture is present at the time when conditions are suitable for plant growth.

Ustifluvents: fluvents with an ustic moisture regime. These soils are on river flood plains.

Volcanic tuff: a compacted deposit of volcanic ash and dust that may contain up to 50% sediments such as sand or clay.

REFERENCES

American Association of State Highway Officials, 1955, Standard Specifications for Highway Materials and Methods of Sampling and Testing.

Averitt, P., 1972, "Coal," Geologic Atlas of the Rocky Mountain Region, Denver: Rocky Mtn. Assoc. of Geologists, pp. 297-299.

Bradley, W. H., 1931, Origin and Microfossils of the Oil Shale of the Green River Formation of Colorado and Utah, U. S. Geol. Survey Prof. Paper 168.

Bradley, W. H., 1970, "Green River Oil Shale: Concept of Origin Extended," Geol. Soc. America Bull., V. 81, pp. 985-1000.

Butler, A. P., 1972, "Uranium," Geologic Atlas of the Rocky Mountain Region, Denver: Rocky Mtn. Assoc. of Geologists, pp. 315-317.

Cashion, W. B., 1964, The Distribution and Quality of Oil Shale in the Green River Formation of the Uinta Basin, Utah-Colorado, U. S. Geol. Survey Prof. Paper 501-0.

Cashion, W. B., 1967, Geology and Fuel Resources of the Green River Formation: Southeastern Uinta Basin, Utah and Colorado, U. S. Geol. Survey Prof. Paper 548.

Cashion, W. B. and Brown, J. H., Jr., 1956, Geology of the Bonanza-Dragon Oil Shale Area, Uintah County, Utah and Rio Blanco County, Colorado, U. S. Geol. Survey Oil and Gas Inv. Map OM 153.

Cashion, W. B. and Donnell, J. R., 1974, Revision of the Nomenclature of the Upper Part of the Green River Formation, Piceance Creek Basin, Colorado and Eastern Uinta Basin, Utah, U. S. Geol. Survey Bull. 1394-G.

Clark, J., 1957, "Geomorphology of the Uinta Basin," Guidebook to the Geology of the Uinta Basin, Intermountain Assoc. of Petroleum Geologists, Eighth Ann. Field Conf., 1957, Salt Lake City, UT, pp. 17-21.

Coffman, J. L. and von Hake, C. A., 1973, Earthquake History of the United States, U. S. Department of Commerce, Natl. Oceanic and Atmospheric Adm. Pub. 41-1, pp. 207.

Covington, R. E., 1957, "The Bituminous Sandstones of the Asphalt Ridge Area, Northeastern Utah," Guidebook to the Geology of the Uinta Basin, Intermountain Assoc. of Petroleum Geologists, Eighth Ann. Field Conf., 1957, Salt Lake City, UT, pp. 172-175.

Curtis, G. R., 1972, "Petroleum Impregnated Rocks and Shallow Oil Pools," *Geologic Atlas of the Rocky Mountain Region*, Denver: Rocky Mtn. Assoc. of Geologists, pp. 293-296.

Dane, C. H., 1954, "Stratigraphic and Facies Relationships of Upper Part of Green River Formation and Lower Part of Uinta Formation in Duchesne, Uintah, and Wasatch Counties, Utah," *Am. Assoc. Petroleum Geologists Bull.*, V.38, No. 3, pp. 405-425.

Dury, G. H., 1969. *Perspectives on Geomorphis Processes*, Assoc. of Am. Geographers, Comm. on Coll. Geog. Resource Paper No. 3.

Hite, R. J., 1972, "Gypsum," *Geologic Atlas of the Rocky Mountain Region*, Denver: Rocky Mtn. Assoc. of Geologists, pp. 318-321.

Kay, J. L., 1934. "The Tertiary Formations of the Uinta Basin, Utah," *Carnegie Museum Annals*, V. 23, pp. 357-372.

McDonald, R. E., 1972, "Eocene and Paleocene Rocks of the Southern and Central Basins," *Geologic Atlas of the Rocky Mountain Region*, Denver: Rocky Mtn. Assoc. of Geologists, pp. 243-256.

Picard, M. D., 1955, "Subsurface Stratigraphy and Lithology of Green River Formation in Uinta Basin, Utah," *Am. Assoc. Petroleum Geologists Bull.*, V. 39, No. 1, pp. 75-102.

Ritzma, H. R., 1957, "Tectonic Map, Uinta Basin, Northeast Utah," *Guidebook to the Geology of the Uinta Basin*, Intermountain Assoc. of Petroleum Geologists, Eighth Ann. Field Conf., 1957, Salt Lake City, UT.

Ritzma, H. R., 1972, "Petroleum-the Uinta Basin," *Geologic Atlas of the Rocky Mountain Region*, Denver: Rocky Mtn. Assoc. of Geologists, pp. 276-278.

U. S. Dept. of Agriculture, Soil Conservation Service, 1967, *Soil Survey Laboratory Methods and Procedures for Collecting Soil Samples*, Soil Survey Inv. Rept. No. 1.

U. S. Dept. of Agriculture, Soil Conservation Service, 1971, *Guide for Interpreting Engineering Uses of Soils*, pp. 87.

U. S. Dept. of Agriculture, Soil Survey Staff, 1951, *Soil Survey Manual*, U.S.D.A. Handbook No. 18.

U. S. Dept. of Agriculture, Soil Survey Staff, 1973, *Soil Taxonomy-a Basic System of Soil Classification for Making and Interpreting Soil Surveys*.

APPENDICES

APPENDIX V-1

UTAH STATE UNIVERSITY
Soils Laboratory
Logan, Utah
SOIL ANALYSIS REPORT

COLLECTED BY Dr. A. R. Southard DATE LOCATION Oil Shale Ua and Ub

Soil	LABORATORY NUMBER	COLLECTOR'S NUMBER	DEPTH cm	HORIZON	PARTICLE SIZE DISTRIBUTION (in mm) (percent) VERY COARSE SAND 2-1	COARSE SAND 1-0.5	MEDIUM SAND 0.5-0.25	FINE SAND 0.25-0.10	VERY FINE SAND 0.10-0.05	% SILT – Hydrometer –	% CLAY	% Sand	% > 2 mm.	TEXTURAL CLASS
A	36	22	0-9		13	7	3	5	1	49	16	35	29	L
	37		9-25		12	7	3	7	12	50	15	35	39	L
	38		25-36		17	10	6	12	14	39	16	45	59	L
	39		36-46		28	16	8	10	5	29	13	58	57	SL
B -	40	63	0-8		9	8	7	17	11	38	20	42	44	L
Bs	41		8-14		7	4	3	7	8	55	21	24	40	SiL
	42		14-27		6	3	1	5	11	60	25	15	52	SiL

Soil		pH SATURATED PASTE	pH 1:5	ORGANIC MATTER ORGANIC MATTER %	ORGANIC CARBON %	NITROGEN %	C/N	TOTAL SOLUBLE SALTS %	ELECTRICAL CONDUCTIVITY EC x 10^3 MILLIMHOS PER CM @ 25°C	CaCO3 equivalent per cent	GYPSUM me/100g SOIL	GYPSUM %	MOISTURE TENSIONS 1/3 ATMOS. %	15 ATMOS. %
A	36	7.5			1.8				.7	32.1			19.4	8.8
	37	7.6			1.8				.6	42.6			22.9	12.4
	38	7.8			2.6				.5	52.0			27.1	17.0
	39	7.9			.9				.5	52.0			20.2	6.6
Bs	40	8.0			.5				.7	7.2			17.3	8.0
	41	7.5			.7				1.7	11.4			23.5	10.2
	42	8.3			.5				2.5	14.2			25.2	10.1

Soil		CATION EXCHANGE CAPACITY	Extractable CATIONS Ca (NH$_4$OAc me/100g)	Mg	Na	K	Avail P ppm	SATURATION EXTRACT SOLUBLE Na (milliequivalents per liter)	K	CO$_3$	HCO$_3$	Cl	SO$_4$	PER CENT MOISTURE AT SATURATION
A	36			3.1	.6	.6	7.9							44
	37			4.4	.4	.2	1.9							54
	38			5.7	.5	.1	3.4							70
	39			4.4	.3	<.1	1.4							34
Bs	40			1.5	.9	.2	4.9							28
	41			3.3	5.8	.2	2.1							42
	42			3.5	10.9	.2	.5							44

UTAH STATE UNIVERSITY

Soils Laboratory

Logan, Utah

SOIL ANALYSIS REPORT

COLLECTED BY Dr. A. Southard DATE ________ LOCATION Oil Shale Ua and Ub

Soil	LABORATORY NO.	COLLECTOR'S NO.	DEPTH in cm.	HORIZON	PARTICLE SIZE DISTRIBUTION (in mm.) (percent) VERY COARSE SAND 2-1	COARSE SAND 1-0.5	MEDIUM SAND 0.5-0.25	FINE SAND 0.25-0.10	VERY FINE SAND 0.10-0.05	% SILT - Hydrometer --	% CLAY	% Sand	% > 2 mm	TEXTURAL CLASS
As	2	37-0-8			11	10	9	24	14	27	11	62	16	SL
	3	8-22			14	9	6	20	15	29	10	61	47	SL
	4	22-36			12	6	3	10	15	45	12	43	39	L
	1	36-44			insuff. sample								57	---
As	5	38 0-12			8	8	11	27	9	28	10	62	28	SL
	6	12-27			8	5	3	6	10	57	9	34	37	SiL
	7	27-53			16	9	6	12	9	46	9	.45	21	L

Soil		pH SATURATED PASTE	pH 1:5	ORGANIC MATTER ORGANIC MATTER %	ORGANIC CARBON %	NITROGEN %	C/N	TOTAL SOLUBLE SALTS %	ELECTRICAL CONDUCTIVITY EC × 10³ MILLIMHOS PER CM @ 25°C	CaCO3 equivalent per cent	GYPSUM me/100g SOIL	GYPSUM %	MOISTURE TENSIONS 1/3 ATMOS. %	15 ATMOS. %
As	2	8.1			.9				.5	11.3			12.9	6.1
	3	8.5			.8				.9	11.1			16.5	8.3
	4	8.4			.8				5.8	10.8			24.3	8.2
	1	8.4			.6				20	8.3			insuf. sample	
As	5	8.1			2.4				.6	14.8			18.3	11.4
	6	8.5			1.1				.3	23.5			31.6	9.4
	7	8.5			.6				.5	41.3			19.4	6.4

Soil		CATION EXCHANGE CAPACITY	Extractable CATIONS ppm Ca	Mg	Na	K	Avail P ppm	SATURATION EXTRACT SOLUBLE Na	K	CO_3	HCO_3	Cl	SO_4	PER CENT MOISTURE AT SATURATION
		← NH$_4$OAc				→		← milliequivalents per liter					→	
As	2			1.4	.4	.4	5.7							30
	3			2.4	1.4	.1	.9							42
	4			3.9	9.4	.1	.3							44
	1			5.7	12.5	.1	1.4							41
As	5			1.0	.4	.2	4.0							49
	6			2.6	.7	.1	.3							58
	7			3.5	.7	<.1	.3							41

UTAH STATE UNIVERSITY

Soils Laboratory

Logan. Utah

SOIL ANALYSIS REPORT

COLLECTED BY Dr. A. Southard DATE LOCATION

Soil	LABORATORY NUMBER	COLLECTOR'S NUMBER	DEPTH cm.	HORIZON	PARTICLE SIZE DISTRIBUTION (in mm.) (percent) VERY COARSE SAND 2-1	COARSE SAND 1-0.5	MEDIUM SAND 0.5-0.25	FINE SAND 0.25-0.10	VERY FINE SAND 0.10-0.05	% SILT	% CLAY	% Sand	% > 2 mm.	TEXTURAL CLASS
										- Hydrometer --				
F	8	#39	0-4		2	11	30	29	8	9	8	83	4	LS
	9		4-17		6	13	30	25	6	11	11	78	7	SL
	10		17-35		11	19	27	21	5	8	10	82	25	LS
Ds	11	#40	0-6		7	9	15	27	12	22	12	66	18	SL
	12		6-31		11	10	13	23	12	24	9	67	21	SL
	13		31-137		12	12	14	23	11	21	9	70	23	SL

		pH		ORGANIC MATTER							GYPSUM		MOISTURE TENSIONS	
		SATURATED PASTE	1:5	ORGANIC MATTER %	ORGANIC CARBON %	NITROGEN %	C/N	TOTAL SOLUBLE SALTS %	ELECTRICAL CONDUCTIVITY EC × 10³ MILLIMHOS PER CM @25°C	CaCO3 equivalent per cent	me./100g SOIL	%	1/3 ATMOS %	15 ATMOS. %
F	8	8.1			.5				.6	3.0			8.1	4.6
	9	8.2			.5				.5	3.7			9.3	5.8
	10	8.5			.5				.3	6.8			10.4	6.3
Ds	11	8.0			.9				.9	13.4			13.9	6.0
	12	8.3			.5				.4	9.7			11.9	5.7
	13	8.2			.5				1.9	7.8			12.9	6.2

			Extractable CATIONS ppm					SATURATION EXTRACT SOLUBLE						
		CATION EXCHANGE CAPACITY	Ca	Mg	Na	K	Avail P ppm	Na	K	CO_3	HCO_3	Cl	SO_4	PER CENT MOISTURE AT SATURATION
		←	NH_4OAc			→		←	milliequivalents per liter				→	
F	8			1.0	.3	.4	16							29
	9			1.3	.5	.2	3.2							32
	10			1.0	.5	<.1	1.0							38
Ds	11			1.9	.4	1.1	24							34
	12			1.9	.4	.7	4.9							32
	13			2.3	2.8	.2	3.5							33

UTAH STATE UNIVERSITY

Soils Laboratory

Logan, Utah

SOIL ANALYSIS REPORT

COLLECTED BY Dr. A. Southard DATE ____________ LOCATION Oil Shale Ua and Ub

Soil	LAB. NO.	COLLECTOR NO.	DEPTH cm.	HORIZON	PARTICLE SIZE DISTRIBUTION (in mm) (percent)								%	TEXTURAL CLASS
					VERY COARSE SAND 2-1	COARSE SAND 1-0.5	MEDIUM SAND 0.5-0.25	FINE SAND 0.25-0.10	VERY FINE SAND 0.10-0.05	% SILT	% CLAY	% Sand	> 2 mm.	
										– Hydrometer --				
As	14	#42	0-6		9	16	15	19	8	23	10	67	29	SL
	15		6-13		10	15	14	20	9	28	10	62	27	SL
	16		13-41		15	10	8	17	9	36	10	54	31	SL
	17		41-60		14	9	5	13	14	40	13	47	28	L
Ds	18	#45	0-4		8	7	9	22	13	31	12	57	22	SL
	19		4-23		9	10	12	26	12	25	12	63	31	SL
	20		23-40		7	9	11	24	12	26	11	63	18	SL
	21		40-76		7	7	9	22	13	26	13	61	18	SL
	22		76-121		11	13	13	21	8	20	13	67	41	SL

Soil		pH		ORGANIC MATTER				TOTAL SOLUBLE SALTS %	ELECTRICAL CONDUCTIVITY EC × 10³ MILLIMHOS PER CM @ 25°C	CaCO3 equivalent per cent	GYPSUM		MOISTURE TENSIONS	
		SATURATED PASTE	1:5	ORGANIC MATTER %	ORGANIC CARBON %	NITROGEN %	C/N				me./100g SOIL	%	1/3 ATMOS. %	15 ATMOS. %
As	14	8.1			1.5				.5	7.4			15.0	8.0
	15	8.1			2.4				.3	10.7			20.6	12.7
	16	8.5			1.2				.4	13.6			20.3	8.7
	17	8.6			.8				1.9	12.6			21.3	8.9
Ds	18	7.9			.8				.4	6.0			13.8	6.2
	19	8.2			1.0				.3	8.1			12.9	7.2
	20	8.3			.6				2.4	8.3			13.8	7.5
	21	8.2			.4				13.0	7.6			14.9	7.8
	22	8.3			.2				19.0	9.7			13.7	7.1

Soil		CATION EXCHANGE CAPACITY	Extractable CATIONS ppm				Avail P ppm	SATURATION EXTRACT SOLUBLE						PER CENT MOISTURE AT SATURATION
			Ca	Mg	Na	K		Na	K	CO₃	HCO₃	Cl	SO₄	
		←	NH₄OAc			→		← milliequivalents per liter					→	
As	14			.8	.3	.2	3.8							38
	15			1.0	.4	.1	2.2							58
	16			2.7	1.0	.1	.5							52
	17			5.2	6.4	.1	.3							51
Ds	18			.7	.3	.4	3.3							29
	19			1.2	.4	.2	1.0							41
	20			2.0	3.3	.1	.3							34
	21			2.4	9.7	.1	.3							35
	22			2.9	14.0	.1	1.5							33

UTAH STATE UNIVERSITY

Soils Laboratory

Logan, Utah

SOIL ANALYSIS REPORT

COLLECTED BY Dr. A. Southard DATE LOCATION Oil Shale Ua and Ub

					PARTICLE SIZE DISTRIBUTION (in mm.) (percent)									
Soil	LABORATORY NUMBER	COLLECTOR'S NUMBER	DEPTH IN cm.	HORIZON	VERY COARSE SAND 2-1	COARSE SAND 1-0.5	MEDIUM SAND 0.5-0.25	FINE SAND 0.25-0.10	VERY FINE SAND 0.10-0.05	% SILT	% CLAY	% Sand	% > 2 mm	TEXTURAL CLASS
										– Hydrometer	– –			
A	23	#46	0-6		18	9	4	8	11	40	13	47	23	L
	24		6-20		12	7	3	5	6	62	13	25	35	SiL
	25		20-45		12	7	3	5	6	59	14	27	34	SiL
N	26	#48	0-9		1	1	3	16	33	33	10	57	1	SL
	27		9-20		<1	1	2	12	26	34	27	39	1	L
	28		20-34		<1	1	2	8	15	35	38	27	0	CL
	29		34-55		<1	1	3	12	16	35	31	34	1	CL
	30		55-89		<1	1	2	7	21	40	30	30	0	CL
	31		89-158		1	2	2	8	17	46	26	28	2	L

		pH		ORGANIC MATTER							GYPSUM		MOISTURE TENSIONS	
Soil		SATURATED PASTE	1:5	ORGANIC MATTER %	ORGANIC CARBON %	NITROGEN %	C/N	TOTAL SOLUBLE SALTS %	ELECTRICAL CONDUCTIVITY EC x 10^3 MILLIMHOS PER CM @25°C	CaCO3 equivalent per cent	me./100g SOIL	%	1/3 ATMOS. %	15 ATMOS. %
A	23	8.0			1.1				.5	8.3			20.1	7.3
	24	8.3			1.2				.4	23.4			28.9	9.6
	25	8.7			1.0				1.1	16.4			32.5	9.1
N	26	8.7			.3				.9	4.5			9.8	3.6
	27	8.9			.3				2.4	10.5			26.4	11.3
	28	8.5			.3				14.0	15.2			26.8	14.0
	29	8.2			.2				33.0	15.5			20.2	10.5
	30	8.1			.2				22.0	15.4			18.9	8.3
	31	8.3			.1				20.0	11.7			18.9	8.3

			Extractable CATIONS ppm					SATURATION EXTRACT SOLUBLE						
Soil		CATION EXCHANGE CAPACITY	Ca	Mg	Na	K	Avail P ppm	Na	K	CO3	HCO3	Cl	SO4	% Moist. at Sat.
		←	NH4OAc			→		←	milliequivalents per liter				→	
A	23			2.2	.4	.3	7.3							39
	24			5.0	.9	.1	1.5							56
	25			8.6	3.0	.1	1.5							57
N	26			2.4	1.7	.9	6.4							28
	27			3.9	11.4	.3	3.4							48
	28			5.7	19.8	.2	1.8							62
	29			5.7	19.6	.2	1.0							48
	30			5.0	15.7	.1	1.0							48
	31			5.0	13.5	.2	.6							49

UTAH STATE UNIVERSITY

Soils Laboratory

Logan, Utah

SOIL ANALYSIS REPORT

COLLECTED BY Dr. A. Southard DATE ______ LOCATION Oil Shale Ua and Ub

Soil	Laboratory Number	Collector's Number	Depth in cm.	Horizon	Particle Size Distribution (in mm.) (percent) Very Coarse Sand 2-1	Coarse Sand 1-0.5	Medium Sand 0.5-0.25	Fine Sand 0.25-0.10	Very Fine Sand 0.10-0.05	% Silt – Hydrometer	% Clay Hydrometer	% Sand Hydrometer --	% > 2 mm.	Textural Class
A	32	#50	0-11		4	3	2	10	18	44	16	40	21	L
	33		11-30		12	6	3	10	13	44	15	41	41	L
	34		30-42		21	13	6	11	8	35	14	51	60	L
	35		42-49		23	14	6	16	7	27	17	56	57	SL

Soil		pH Saturated Paste	pH 1:5	Organic Matter Organic Matter %	Organic Matter Organic Carbon %	Organic Matter Nitrogen %	Organic Matter C/N	Total Soluble Salts %	Electrical Conductivity EC x 10^3 Millimhos per cm @25°C	$CaCO_3$ equivalent per cent	Gypsum me./100g Soil	Gypsum %	Moisture Tensions 1/3 Atmos. %	Moisture Tensions 15 Atmos. %
A	32	8.0			1.1				.8	3.9			19.4	9.4
	33	8.2			1.1				.4	15.9			20.7	9.8
	34	9.0			.8				1.1	10.9			26.1	11.2
	35	8.5			.7				5.4	8.5			24.2	11.4

Soil		Cation Exchange Capacity	Extractable Cations ppm Ca	Extractable Cations ppm Mg	Extractable Cations ppm Na	Extractable Cations ppm K	Avail P ppm	Saturation Extract Soluble Na	Saturation Extract Soluble K	Saturation Extract Soluble CO_3	Saturation Extract Soluble HCO_3	Saturation Extract Soluble Cl	Saturation Extract Soluble SO_4	Per Cent Moisture at Saturation
		← NH_4OAc				→		← milliequivalents per liter					→	
A	32			2.9	1.0	.8	7.4							36
	33			2.9	1.4	.1	1.1							56
	34			2.6	10.9	.8	1.0							46
	35			3.5	13.5	.2	3.5							46

UTAH STATE UNIVERSITY
Soils Laboratory
Logan, Utah

SOIL ANALYSIS REPORT

COLLECTED BY Dr. A. R. Southard DATE ____________ LOCATION Oil Shale Ua and Ub

					PARTICLE SIZE DISTRIBUTION (in mm.) (percent)									
Soil	LABORATORY NUMBER	COLLECTOR'S NUMBER	DEPTH IN cm.	HORIZON	VERY COARSE SAND 2-1	COARSE SAND 1-0.5	MEDIUM SAND 0.5-0.25	FINE SAND 0.25-0.10	VERY FINE SAND 0.10-0.05	% SILT – Hydrometer –	% CLAY	% Sand	% > 2 mm.	TEXTURAL CLASS
As	52	53	0-8		14	8	6	14	14	31	13	56	32	SL
	53		8-23		10	7	4	11	11	46	10	44	26	L
	54		23-45		11	7	4	11	13	52	10	38	35	SiL
Ds	55	58	0-10		1	2	5	34	24	29	10	61	2	SL
	56		10-34		6	9	16	35	12	14	10	76	6	SL
	57		34-72		12	15	20	29	7	10	6	84	38	LS
	58		72-127		23	14	13	20	8	14	9	77	61	SL

		pH		ORGANIC MATTER						GYPSUM		MOISTURE TENSIONS	
Soil		SATURATED PASTE	1-5	ORGANIC MATTER %	ORGANIC CARBON %	NITROGEN %	C/N	TOTAL SOLUBLE SALTS %	ELECTRICAL CONDUCTIVITY EC × 10³ MILLIMHOS PER CM @ 25°C	CaCO3 equivalent per cent	me./100g SOIL	%	1/3 ATMOS. %	15 ATMOS. %
As	52	7.9			1.5				.5	4.9			17.4	9.7
	53	7.8			1.8				.5	13.4			24.8	12.4
	54	8.7			.7				2.5	12.4			27.6	13.3
Ds	55	9.9			.5				5.0	6.2			11.3	5.8
	56	10.4			.3				12.0	5.7			8.7	6.6
	57	8.0			.3				15.0	5.3			7.6	6.0
	58	8.0			.2				3.5	14.6			10.8	5.8

			Extractable CATIONS					SATURATION EXTRACT SOLUBLE						
Soil		CATION EXCHANGE CAPACITY	Ca	Mg	Na	K	Avail P ppm	Na	K	CO₃	HCO₃	Cl	SO₄	PER CENT MOISTURE AT SATURATION
		←	NH₄OAc me/100g			→		←	milliequivalents per liter				→	
As	52			.6	.4	.4	11							41
	53			.7	.9	.1	1.4							58
	54			1.1	8.4	.1	.6							56
Ds	55			1.2	6.9	1.3	8.9							41
	56			.4	10.3	.3	10.9							30
	57			.9	3.1	.1	2.1							26
	58			1.5	1.4	.1	1.8							28

UTAH STATE UNIVERSITY
Soils Laboratory
Logan, Utah
SOIL ANALYSIS REPORT

COLLECTED BY Dr. A. R. Southard DATE ____ LOCATION Oil Shale Ua and Ub

Soil	LABORATORY NUMBER	COLLECTOR'S NUMBER	DEPTH IN cm.	HORIZON	PARTICLE SIZE DISTRIBUTION (in mm.) (percent) VERY COARSE SAND 2-1	COARSE SAND 1-0.5	MEDIUM SAND 0.5-0.25	FINE SAND 0.25-0.10	VERY FINE SAND 0.10-0.05	% SILT – Hydrometer –	% CLAY	% Sand	% > 2 mm.	TEXTURAL CLASS
E	43	55	0-5		3	1	2	14	41	31	9	60	4	SL
	44		5-15		2	2	3	12	35	35	10	55	3	SL
	45		15-40		3	2	3	12	31	39	10	51	5	L
	46		40-120		3	4	4	14	25	38	10	52	6	SL
	47		120-160		3	4	6	16	21	34	12	54	9	SL
A	48	54	0-8		8	5	6	20	17	29	13	58	20	SL
	49		8-17		8	5	6	22	18	29	13	58	16	SL
	50		17-30		16	8	6	15	10	27	19	54	38	SL
	51		30-33		22	13	5	8	5	33	20	47	38	L

Soil		pH SATURATED PASTE	pH 1:5	ORGANIC MATTER ORGANIC MATTER %	ORGANIC CARBON %	NITROGEN %	C/N	TOTAL SOLUBLE SALTS %	ELECTRICAL CONDUCTIVITY EC × 10³ MILLIMHOS PER CM. @ 25°C	CaCO3 equivalent per cent	GYPSUM me /100g SOIL	GYPSUM %	MOISTURE TENSIONS 1/3 ATMOS. %	15 ATMOS. %
E	43	7.7			.7				.8	2.9			10.0	4.8
	44	7.8			.4				.6	3.1			11.0	5.5
	45	7.8			.3				.4	4.9			12.4	5.9
	46	8.0			.4				.8	4.9			13.5	6.3
	47	7.7			.3				16.0	6.0			14.6	6.4
A	48	7.9			.8				.5	6.8			15.0	7.5
	49	7.9			.7				.3	9.3			17.2	9.2
	50	7.9			.8				.3	11.5			20.4	12.0
	51	8.0			.8				.4	7.3			21.0	11.1

Soil		CATION EXCHANGE CAPACITY	Extractable CATIONS Ca	Mg	Na	K	Avail P ppm	SATURATION EXTRACT SOLUBLE Na	K	CO₃	HCO₃	Cl	SO₄	PER CENT MOISTURE AT SATURATION
		← NH₄OAc me/100g →						← milliequivalents per liter →						
E	43			2.7	.3	1.4	24							33
	44			2.5	.3	.5	2.6							28
	45			2.7	.4	.2	1.8							33
	46			3.4	1.1	.2	1.9							35
	47			4.4	6.7	.3	9.2							34
A	48			10.4	.3	.4	7.1							29
	49			1.5	.3	.1	.6							39
	50			1.9	.5	.1	.5							42
	51			1.9	.8	.1	.6							41

UTAH STATE UNIVERSITY

Soils Laboratory

Logan, Utah

SOIL ANALYSIS REPORT

COLLECTED BY Dr. A. Southard DATE ______ LOCATION ______

Soil	LABORATORY NUMBER	COLLECTOR'S NUMBER	DEPTH IN cm.	HORIZON	PARTICLE SIZE DISTRIBUTION (in mm.) (percent)								%	TEXTURAL CLASS	
					VERY COARSE SAND 2-1	COARSE SAND 1-0.5	MEDIUM SAND 0.5-0.25	FINE SAND 0.25-0.10	VERY FINE SAND 0.10-0.05	% SILT	% CLAY	% Sand	> 2 mm.		
										– Hydrometer –					
Ds	1	#64	0-10		9	9	11	21	11	27	11	62	13	SL	
	2		10-40		14	14	14	23	9	19	11	70	24	SL	
	3		40-65		12	14	13	20	9	23	12	65	20	SL	
	4		65-113		11	16	15	21	9	21	11	68	15	SL	
	5		113-150		12	12	13	22	11	23	10	67	21	SL	
As	6	#66	0-5		8	10	15	27	9	24	11	65	20	SL	
	7		5-15		7	10	14	28	10	21	10	69	40	SL	
	8		15-30		13	11	12	30	9	19	13	68	52	SL	

Soil		pH		ORGANIC MATTER				TOTAL SOLUBLE SALTS %	ELECTRICAL CONDUCTIVITY EC × 10³ MILLIMHOS PER CM @25°C	CaCO3 equivalent per cent	GYPSUM		MOISTURE TENSIONS		Liquid Limit %
		SATURATED PASTE	1:5	ORGANIC MATTER %	ORGANIC CARBON %	NITROGEN %	C/N				me /100g SOIL	%	1/3 ATMOS. %	15 ATMOS. %	
Ds	1	8.1			1.1				.6	5.8			14.2	6.0	23
	2	8.1			.5				.4	5.9			11.8	5.6	21
	3	8.1			.4				.6	9.2			12.4	6.2	21
	4	8.1			.4				2.6	7.5			11.6	5.8	21
	5	8.1			.3				28.0	7.2			13.7	6.0	20
As	6	8.1			1.1				.5	12.6			14.1	6.7	24
	7	8.1			1.4				.4	9.8			15.2	7.5	28
	8	8.0			1.8				.4	17.8			20.3	11.4	36

Soil		CATION EXCHANGE CAPACITY	Extractable CATIONS				Avail P ppm	SATURATION EXTRACT SOLUBLE						PER CENT MOISTURE AT SATURATION	Plastic Index %
			Ca	Mg	Na	K		Na	K	CO3	HCO3	Cl	SO4		
		←	NH4OAc me/100g			→		←	milliequivalents per liter				→		
Ds	1			1.1	.3	.3	17							32	NP
	2			.9	.5	.1	3.6							30	NP
	3			.5	.8	.1	3.7							31	NP
	4			.9	3.8	.1	4.1							33	NP
	5			1.5	12.9	.2	2.4							29	NP
As	6			.5	.4	.2	2.6							38	NP
	7			.7	.4	.1	1.2							46	NP
	8			.8	.4	.1	1.5							50	NP

UTAH STATE UNIVERSITY
Soils Laboratory
Logan, Utah
SOIL ANALYSIS REPORT

COLLECTED BY Dr. A. Southard DATE LOCATION

Soil	Laboratory Number	Collector's Number	Depth in cm.	Horizon	Particle size distribution (in mm) (percent)								%	Textural Class	
					Very Coarse Sand 2-1	Coarse Sand 1-0.5	Medium Sand 0.5-0.25	Fine Sand 0.25-0.10	Very Fine Sand 0.10-0.05	Silt - Hydrometer -	Clay	% Sand	> 2 mm.		
As	9	#67	0-5		10	9	12	19	9	27	14	59	39	SL	
	10		5-12		13	8	8	20	15	28	15	57	60	SL	
	11		12-25		14	9	7	16	12	34	14	52	67	SL	
	12		25-35		18	12	8	20	11	22	13	65	63	SL	
A	13	#68	0-8		7	4	4	15	18	38	14	48	28	L	
	14		8-20		10	6	4	13	12	40	20	40	55	L	
	15		20-33		22	11	5	8	7	35	17	48	44	L	
	16		33-50		17	10	6	13	10	36	17	47	77	L	

Soil		pH		Organic Matter				Total Soluble Salts %	Electrical Conductivity $EC \times 10^3$ Millimhos per cm @ 25°C	CaCO3 equivalent per cent	Gypsum		Moisture Tensions		Liquid Limit %
		Saturated Paste	1:5	Organic Matter %	Organic Carbon %	Nitrogen %	C/N				me./100g Soil	%	1/3 Atmos. %	15 Atmos. %	
As	9	8.0			1.4				.5	7.0			17.7	8.1	27
	10	8.2			1.5				.6	8.6			21.2	9.9	37
	11	8.7			1.2				1.0	10.7			23.9	9.4	35
	12	8.9			.6				1.8	7.9			18.2	6.7	30
A	13	8.1			1.5				.5	2.9			17.3	7.8	24
	14	8.1			1.4				.5	8.4			23.0	11.7	33
	15	8.6			1.0				.8	9.8			26.0	9.9	31
	16	8.7			.9				1.2	5.3			25.4	11.8	32

Soil		Cation Exchange Capacity	Extractable Cations				Avail P ppm	Saturation Extract Soluble						Per Cent Moisture at Saturation	Plasti Index %
			Ca	Mg	Na	K		Na	K	CO_3	HCO_3	Cl	SO_4		
		← NH_4OAc me/100g →						← milliequivalents per liter →							
As	9			.4	.4	.3	6.9							38	NP
	10			1.0	1.3	.1	1.6							52	NP
	11			1.6	7.2	.1	1.1							51	NP
	12			1.6	8.4	.1	.8							40	NP
A	13			1.0	.5	.3	7.5							32	NP
	14			1.1	1.1	.2	2.1							47	3
	15			.6	4.6	.1	1.1							44	3
	16			.6	10.4	.2	2.8							48	4

UTAH STATE UNIVERSITY
Soils Laboratory
Logan, Utah
SOIL ANALYSIS REPORT

COLLECTED BY Dr. A. Southard DATE LOCATION

Soil	Laboratory Number	Collector's Number	Depth cm.	Horizon	Particle Size Distribution (in mm) (percent): Very Coarse Sand 2-1	Coarse Sand 1-0.5	Medium Sand 0.5-0.25	Fine Sand 0.25-0.10	Very Fine Sand 0.10-0.05	% Silt – Hydrometer	% Clay	% Sand	% > 2 mm	Textural Class
	17	#75	0-10		7	1	1	1	2	62	23	15	0	SiL
W	18		10-20		<1	1	1	5	9	60	17	23	0	SiL
	19		20-30		1	1	<1	1	2	59	38	3	0	SiCL
	20		30-65		<1	<1	<1	1	2	64	34	2	0	SiCL
	21		65-90		<1	<1	1	40	31	17	8	75	0	SL
	22		90-130		<1	<1	<1	29	37	23	8	69	0	SL
	23		130-195		1	1	<1	2	4	68	17	15	0	SiL

Soil		pH: Saturated Paste	pH: 1:5	Organic Matter: Organic Matter %	Organic Carbon %	Nitrogen %	C/N	Total Soluble Salts %	Electrical Conductivity EC x 10³ Millimhos per cm @ 25°C	CaCO3 equivalent per cent	Gypsum: me./100g soil	Gypsum %	Moisture Tensions: 1/3 Atmos %	15 Atmos. %	Liqui Limi %
	17	8.2			5.1				1.4	11.3			34.3	14.7	47
W	18	8.2			1.1				1.5	11.0			22.2	8.4	26
	19	8.0			1.2				14.0	12.0			32.0	15.4	39
	20	8.1			1.0				24.0	11.4			30.9	12.6	33
	21	8.2			.3				16.0	6.0			7.7	3.8	*
	22	8.3			.5				16.0	7.1			9.8	4.1	*
	23	8.1			.8				28.0	12.3			31.0	9.3	31

*Too Sandy

Soil		Cation Exchange Capacity	Extractable Cations (NH₄OAc me/100g): Ca	Mg	Na	K	Avail P ppm	Saturation Extract Soluble (milliequivalents per liter): Na	K	CO₃	HCO₃	Cl	SO₄	Per Cent Moisture at Saturation	Plast Inde %
	17			5.5	1.3	2.7	27							67	8
W	18			4.0	1.6	1.7	2.1							47	2
	19			8.9	7.8	1.5	2.0							65	16
	20			11.5	13.3	.7	2.0							60	12
	21			4.5	4.6	.2	1.2							33	*
	22			5.8	5.7	.1	.7							34	*
	23			10.0	13.3	.3	.7							51	6

*Too Sandy

UTAH STATE UNIVERSITY
Soils Laboratory
Logan. Utah
SOIL ANALYSIS REPORT

COLLECTED BY Dr. A. Southard DATE ____ LOCATION ____

Soil	LABORATORY NUMBER	COLLECTOR'S NUMBER	DEPTH in cm.	HORIZON	PARTICLE SIZE DISTRIBUTION (in mm.) (percent)								%	TEXTURAL CLASS	
					VERY COARSE SAND 2-1	COARSE SAND 1-0.5	MEDIUM SAND 0.5-0.25	FINE SAND 0.25-0.10	VERY FINE SAND 0.10-0.05	% SILT	% CLAY	% Sand	> 2 mm.		
										- Hydrometer -					
E	24	#76	0-10		2	2	3	15	32	31	8	61	2	SL	
	25		10-23		1	1	2	9	23	41	16	43	1	L	
	26		23-47		1	1	1	6	24	45	23	32	0	L	
	27		47-75		3	3	6	20	17	33	19	48	3	L	
	28		75-120		4	6	8	22	14	29	14	57	14	SL	
	29		120-150		8	8	9	22	13	25	14	61	26	SL	

Soil		pH		ORGANIC MATTER				TOTAL SOLUBLE SALTS %	ELECTRICAL CONDUCTIVITY EC × 10³ MILLIMHOS PER CM @25°C	CaCO3 equivalent per cent	GYPSUM		MOISTURE TENSIONS		Liqui Limi %
		SATURATED PASTE	1:5	ORGANIC MATTER %	ORGANIC CARBON %	NITROGEN %	C/N				me./100g SOIL	%	1/3 ATMOS. %	15 ATMOS. %	
E	24	8.2			.6				.5	5.2			11.8	5.0	20
	25	8.2			.5				.7	12.5			17.3	7.1	22
	26	8.4			.4				.7	18.7			23.0	9.4	27
	27	8.6			.3				.9	11.9			21.6	8.6	23
	28	8.1			.4				4.2	9.4			16.8	6.9	23
	29	8.0			.4				18.0	7.8			16.1	6.4	22

Soil		CATION EXCHANGE CAPACITY	Extractable CATIONS				Avail P ppm	SATURATION EXTRACT SOLUBLE						PER CENT MOISTURE AT SATURATION	Plast Inde %
			Ca	Mg	Na	K		Na	K	CO₃	HCO₃	Cl	SO₄		
		← NH₄OAc me/100g →						← milliequivalents per liter →							
E	24			1.5	.3	.4	7.9							31	NP
	25			2.6	.6	.2	1.3							33	NP
	26			3.3	1.7	.2	.8							37	8
	27			2.4	3.5	.2	.7							31	1
	28			1.7	5.2	.1	1.0							34	NP
	29			1.7	10.1	.2	1.4							30	NP

APPENDIX V-2

Infiltration Rates During Various Time Intervals (minutes) By Plot Measured in Inches per Hour

Map Unit	Plot #	3-8	8-13	13-18	18-23	23-28	CN	Sediment Yield	% Bare Soil
D_s Soil (Wet)									
D_sB	1	2.7	2.9	2.7	2.4	2.5	90	0.25	28
D_sB	2	3.4	3.2	3.0	2.8	2.6	95	0.20	"
D_sB	3	2.9	2.8	3.1	2.7	2.9	82	0.03	"
D_sB	7	1.9	1.5	1.8	1.4	1.5	94	0.38	16
D_sB	8	1.6	1.7	1.6	1.5	1.4	95	0.79	"
D_sB	9	1.9	1.5	1.3	1.5	1.1	93	0.33	"
D_sB	10	1.5	1.3	1.4	1.4	1.5	94	0.32	21
D_sB	11	1.4	1.3	1.7	1.5	1.4	95	0.67	"
D_sB	12	2.1	2.0	2.2	2.1	2.3	92	0.78	"
D_sB	13	2.8	2.2	2.7	2.3	1.9	90	0.34	19
D_sB	14	3.1	3.1	3.0	3.1	2.7	85	0.25	"
D_sB	15	2.5	2.4	2.2	2.1	2.1	90	0.28	"
D_sB	16	3.1	2.9	2.8	2.4	2.6	81	0.01	30
D_sB	17	4.1	3.4	3.4	3.4	2.9	62	0.00	"
D_sB	18	3.4	2.7	2.8	2.4	2.0	67	0.00	"
D_sB	19	3.5	4.1	2.9	2.7	2.7	80	0.09	65
D_sB	20	3.9	4.1	3.2	3.7	3.5	80	0.17	"
D_sB	21	2.8	2.8	2.0	2.1	2.2	77	0.28	"
B_s Soil (Wet)									
B_sB	25	0.8	0.6	0.8	0.6	0.7	92	0.69	39
B_sB	26	2.3	0.8	1.0	0.7	0.7	90	0.80	"
B_sB	27	1.7	0.8	1.0	0.6	0.7	96	0.57	"
B_sC	22	1.6	1.0	1.1	1.4	1.0	95	0.86	60
B_sC	23	1.8	1.4	1.5	1.5	1.5	89	0.59	"
B_sC	24	2.1	2.2	2.1	1.9	1.7	88	0.23	"
B_sC	61	1.9	1.3	1.1	0.9	0.9	93	0.12	36
B_sC	62	1.4	1.3	1.0	1.0	1.1	95	0.12	"
B_sC	63	1.8	1.9	1.1	1.1	1.5	93	0.09	"
B_sC	64	2.8	1.1	1.0	1.3	1.7	93	0.21	"
B_sC	65	1.9	1.1	1.4	1.0	1.0	91	0.32	"
B_sC	66	1.7	1.1	1.0	1.3	1.1	94	0.07	"
B_sD	4	2.5	2.4	2.1	2.4	2.3	88	0.42	12
B_sD	5	1.5	1.3	1.5	1.9	1.2	95	2.40	"
B_sD	6	2.0	1.6	1.8	2.0	1.9	91	0.42	"
B_sD	43	1.8	1.6	1.2	1.2	1.6	92	0.15	36
B_sD	44	1.1	0.9	1.1	1.1	1.7	94	----	"
B_sD	45	1.0	1.1	0.5	0.7	0.5	96	0.11	"

Infiltration Rates During Various Time Intervals (minutes) By Plot Measured in Inches per Hour

Map Unit	Plot #	3-8	8-13	13-18	18-23	23-28	CN	Sediment Yield	% Bare Soil
B$_s$D	28	3.7	3.1	3.7	3.4	2.6	86	0.59	43
B$_s$D	29	2.2	2.1	2.4	1.8	1.8	92	4.72	"
B$_s$D	30	4.0	2.0	2.5	2.0	1.7	88	2.02	"
B$_s$E	55	1.6	1.1	1.1	1.3	1.2	93	0.09	42
B$_s$E	56	1.2	0.7	0.8	0.7	0.8	96	0.21	"
B$_s$E	57	1.2	0.6	0.6	0.5	0.5	94	0.21	"
B$_s$E	59	2.6	2.3	2.6	1.8	1.9	86	0.12	"
B$_s$E	60	1.2	0.8	0.9	0.9	1.4	94	0.15	"
				A Soil (Wet)					
AB	49	1.5	1.5	1.1	1.4	1.3	92	0.04	18
AB	50	1.5	1.2	1.0	1.2	1.0	94	0.05	"
AB	51	1.6	1.1	1.1	1.1	1.1	97	0.05	"
AC	46	0.9	0.9	0.9	1.1	1.2	96	0.06	46
AC	47	1.7	1.7	1.9	1.9	2.0	92	0.12	"
AC	48	1.2	1.1	1.1	1.1	1.1	95	0.06	"
AD	34	2.3	2.2	1.9	1.8	1.7	91	0.26	9
AD	35	1.5	1.1	1.1	1.0	0.9	96	1.14	"
AD	36	1.8	1.5	1.2	1.1	1.0	95	0.43	"
AD	52	1.1	0.6	0.8	0.7	0.6	97	0.11	33
AD	53	0.6	1.9	0.6	0.6	0.5	96	0.13	"
AD	54	1.4	1.5	1.2	1.3	1.3	92	0.06	"
				A$_s$ Soil (Wet)					
A$_s$C	85	1.5	1.1	1.0	2.5	0.9	93	0.07	35
A$_s$C	86	1.2	1.7	1.6	2.4	1.2	94	0.05	"
A$_s$C	87	0.7	0.5	0.7	0.8	0.5	97	0.07	"
A$_s$C	88	0.6	0	0.9	0.9	0.4	96	0.17	"
A$_s$C	89	0.8	0.6	0.7	0.6	0.9	97	0.21	"
A$_s$C	90	1.2	1.3	0.7	0.7	1.2	96	0.07	"
				W Soil (Wet)					
W	37	0.8	0.6	0.5	0.6	0.6	97	0.09	48
W	38	0.9	0.3	0	0	0	98	0.18	"
W	39	0.7	0.8	0.8	0.6	0.6	97	0.11	"
W	40	1.6	0.7	0.8	0.7	0.8	94	0.05	"
W	41	0.4	0	0.5	0	0.9	98	0.07	"
W	42	2.2	0.9	1.0	0.5	0.5	96	0.04	"

Infiltration Rates During Various Time Intervals (minutes) By Plot Measured in Inches per Hour

Map Unit	Plot #	3-8	8-13	13-18	18-23	23-28	CN	Sediment Yield	% Bare Soil
N Soil (Wet)									
NB	73	0.4	0.1	0.1	0.3	0.1	98	0.07	100
NB	79	0	0	0	0.1	0	100	0.10	"
NB	75	0.3	0.2	0.2	0.3	0.4	98	0.09	"
NB	76	0	0	0.1	0	0	100	0.10	"
NB	77	0.5	0.9	0.4	0.5	0.5	97	0.29	"
NB	78	0.9	0.9	0.7	0.7	0.3	98	0.38	"
F Soil (Wet)									
F	79	2.1	2.0	1.3	1.7	1.6	91	0.06	44
F	80	1.5	1.6	1.6	1.3	1.4	94	0.04	"
F	81	2.5	2.4	2.3	2.4	2.5	84	0.07	"
F	82	2.8	2.4	2.4	2.4	2.2	84	0.04	"
F	83	1.7	1.6	1.5	1.3	1.2	93	0.05	"
F	89	2.5	2.0	1.7	1.9	1.6	89	0.06	"
E Soil (Wet)									
EB	67	3.0	3.5	1.5	1.5	1.5	86	0.02	"
EB	68	3.7	2.2	2.2	1.9	1.8	86	0.03	"
EB	69	2.8	1.9	2.0	1.7	1.9	85	0.03	"
EB	70	1.2	1.3	0.7	1.1	0.9	96	0.08	"
EB	71	2.3	2.3	1.9	1.7	1.7	90	0.09	"
EB	72	1.1	0.8	1.2	0.9	1.1	96	0.05	"
B Soil (Wet)									
BB	97	0.6	0.4	0.6	0.5	0.6	97	0.07	23
BB	98	0.7	0.5	0.6	0.5	0.6	98	0.07	"
BB	99	0.6	0.2	0.1	0	0	99	0.08	"
BB	100	1.6	0.8	0.5	0.6	0.6	96	0.05	"
BB	101	1.9	0.9	0.9	0.9	0.9	94	0.03	"
BB	102	0.9	0.8	0.7	0.7	1.2	97	0.05	"
BD	91	1.1	0.6	0.7	0.4	0.4	97	0.08	19
BD	92	1.4	1.4	1.3	1.3	1.1	95	0.03	"
BD	93	1.5	1.5	1.4	1.3	0.9	93	0.03	"
BD	94	0.6	0.6	0.5	0.7	0.6	97	0.20	"
BD	95	0.7	0.8	0.6	0.6	0.5	98	0.09	"
BD	96	1.1	0.8	0.7	0.6	0.8	96	0.12	"

Infiltration Rates During Various Time Intervals (minutes) By Plot Measured in Inches per Hour

Map Unit	Plot #	3-8	8-13	13-18	18-23	23-28	CN	Sediment Yield	% Bare Soil
				D Soil (Dry)					
D	1	3.0	3.2	2.6	2.7	2.2	92	0.20	28
D	2	3.4	3.2	3.0	2.8	2.6	87	0.15	"
D	3	3.9	2.8	3.0	2.9	3.3	77	0.01	"
D	7	2.7	1.8	2.2	1.6	1.5	94	0.18	16
D	8	2.5	1.9	1.7	1.5	1.4	94	0.27	"
D	9	3.0	2.0	1.5	1.3	1.2	91	0.16	"
				B_s Soil (Dry)					
B_sD	4	3.0	2.9	3.0	3.0	2.4	87	0.22	12
B_sD	5	3.6	3.4	2.8	2.6	2.5	86	0.47	"
B_sD	6	3.5	2.7	3.3	1.8	2.1	86	0.68	"

APPENDIX V-3

ALBUQUERQUE LABORATORY

REPORT OF ANALYSIS

CUSTOMER AEROVIRONMENT INC.
ATTENTION Dr. Ivar Tombach, Director of Environmental Programs
ADDRESS 145 Vista Avenue
CITY Pasadena, California 91107
S.O. NO. 3050

TYPE OF ANALYSIS DETERMINATION of RADIUM-226 & STRONTIUM-90 in SOIL SAMPLES
CUSTOMER ORDER NUMBER 45327
SAMPLES RECEIVED 12-19-74

Sample Identification	Total Dry Weight (g)	pCi/g (Dry)	
		Ra-226	Sr-90
#39 0-4	2728	0.17 ± 0.01	0.52 ± 0.02
#39 17-35	2545	0.66 ± 0.03	0.00 ± 0.01
#40 0-6	2542	0.87 ± 0.03	0.48 ± 0.02
#40 31-137	2959	0.66 ± 0.03	0.02 ± 0.01

cc: Dr. Stephan Friedland

☐ REPORTED VIA TELEPHONE
☐ REPORTED VIA TWX

PAGE 1 OF 1 PAGE

EBERLINE INSTRUMENT CORPORATION
P.O. BOX 3874 ALBUQUERQUE, NEW MEXICO 87110
PHONE (505) 345 3461 TWX: 910-985-0678

APPROVED BY Ernest A. Sanchez
Ernest A. Sanchez, Manager
Albuquerque Laboratory

DATE 03-13-75

APPENDIX V-3

ALBUQUERQUE LABORATORY

REPORT OF ANALYSIS

CUSTOMER AEROVIRONMENT INC.
ATTENTION Dr. Ivar Tombach, Director of Environmental Programs
ADDRESS 145 Vista Avenue
CITY Pasadena, California 91107
S.O. NO. 3051

TYPE OF ANALYSIS DETERMINATION of GAMMA ISOTOPIC by GeLi in SOIL SAMPLES
CUSTOMER ORDER NUMBER 45327
SAMPLES RECEIVED 12-19-74

Identification:	#39 0-4	#39 17-35	#40 0-6	#40 31-137
Dry Weight (g):	2728	2546	2542	2960

Nuclide Observed	pCi/g (Dry)			
K-40	18 ± 2	11 ± 3	20 ± 3	16 ± 2
Bi-214	0.73 ± 0.29	0.49 ± 0.29	0.79 ± 0.36	0.85 ± 0.31
Tl-208	0.36 ± 0.11	0.19 ± 0.11	0.30 ± 0.12	0.30 ± 0.12
Pb-214	0.65 ± 0.27	0.71 ± 0.24	0.78 ± 0.30	0.74 ± 0.27
Ac-228	0.92 ± 0.52	0.79 ± 0.50	< 0.68	0.94 ± 0.50
Pb-212	1.5 ± 0.3	1.2 ± 0.3	1.0 ± 0.3	1.0 ± 0.3
Cs-137	0.98 ± 0.14	< 0.12	1.6 ± 0.2	0.09 ± 0.08

cc: Dr. Stephan Friedland

☐ REPORTED VIA TELEPHONE
☐ REPORTED VIA TWX

PAGE 1 OF 1 PAGE

EBERLINE INSTRUMENT CORPORATION
P.O. BOX 3874 ALBUQUERQUE, NEW MEXICO 87110
PHONE (505) 345-3461 TWX: 910 985-0678

Ernest A. Sanchez
APPROVED BY Ernest A. Sanchez, Manager
Albuquerque Laboratory

03-13-75
DATE

APPENDIX V-4

EXTRACTABLE ALUMINA IN SPENT SHALE
P AND X HOLES

Footage Interval	Percent Alumina					
	P-1	P-2	P-3	P-4	X-1	X-2
450-460	-	-	-	0.174	-	-
460-470	-	-	-	0.574	-	-
470-480	-	-	-	1.160	-	-
480-490	-	-	-	0.300	-	-
490-500	0.320	-	-	0.921	-	-
500-510	0.317	-	-	0.260	-	-
510-520	0.453	-	-	0.220	-	0.166
520-530	0.598	-	-	0.779	-	0.203
530-540	0.208	-	-	0.901	-	0.221
540-550	0.260	-	0.124	0.800	-	0.137
550-560	0.265	-	0.098	1.196	-	0.143
560-570	0.193	-	0.161	0.886	-	0.934
570-580	0.238	0.141	0.125	0.761	-	0.134
580-590	0.008	0.143	0.147	0.822	-	0.222
590-600	0.265	0.141	0.164	0.262	-	0.120
600-610	0.240	0.141	0.086	0.914	-	0.103
610-620	0.227	0.073	0.114	0.804	-	0.169
620-630	0.171	0.098	0.264	0.902	-	0.259
630-640	0.835	0.146	-	1.445	-	0.184
640-650	0.198	0.188	0.755	0.241	-	0.226
650-660	0.214	0.214	0.609	0.195	-	0.124
660-670	0.192	0.263	0.283	0.162	-	0.098
670-680	1.500	0.173	0.252	0.107	-	0.087
680-690	0.118	0.193	0.292	0.856	-	0.076
690-700	0.062	0.148	0.894	0.722	-	0.112
700-710	0.063	0.212	0.187	0.516	-	0.177
710-720	0.054	0.154	0.135	0.179	-	0.214
720-730	0.201	0.146	0.782	0.093	-	0.702
730-740	0.201	0.157	0.166	0.290	-	0.368
740-750	0.233	0.200	0.227	0.280	-	1.017
750-760	0.164	0.093	0.152	0.260	-	1.121
760-770	0.173	0.101	0.176	1.057	-	-
770-780	0.070	0.090	0.685	0.816	-	-
780-790	0.086	0.101	0.253	1.320	-	-
790-800	0.132	0.081	0.180	1.190	-	-
800-810	0.230	0.170	0.217	0.792	-	-
810-820	0.598	0.140	0.124	0.562	-	-
820-830	0.978	0.137	0.493	1.420	-	-
830-840	0.874	0.080	0.117	0.973	-	-
840-850	1.449	0.064	0.166	1.220	-	-
850-860	1.120	0.070	0.998	0.870	-	-
860-870	0.938	0.081	0.906	1.870	-	-

APPENDIX V-4 (Cont.)

Footage Interval	Percent Alumina					
	P-1	P-2	P-3	P-4	X-1	X-2
870-880	0.496	0.085	0.800	2.070	0.674	-
880-890	0.552	0.070	1.406	1.640	0.240	-
890-900	0.757	0.095	1.114	3.000	0.223	-
900-910	0.586	0.655	0.787	2.280	0.174	-
910-920	0.859	0.100	0.991	2.050	0.180	-
920-930	1.210	0.177	1.053	1.317	0.209	-
930-940	1.312	0.161	0.227	2.112	0.305	-
940-950	1.393	0.208	1.264	2.253	0.263	-
950-960	2.058	0.163	1.414	1.763	0.431	-
960-970	1.447	0.120	1.592	2.572	0.378	-
970-980	1.175	0.076	1.468	2.700	0.247	-
980-990	1.274	0.234	2.357	2.949	0.548	-
990-1000	1.918	0.269	2.591	1.480	0.402	-
1000-1010	1.931	0.068	1.944	1.300	0.193	-
1010-1020	2.079	1.021	1.570	1.830	0.292	-
1020-1030	2.179	2.336	2.264	1.120	0.253	-
1030-1040	2.254	2.625	2.862	0.980	0.211	-
1040-1050	-	*	2.783	1.574	0.264	-
1050-1060	-	*	2.070	1.730	0.292	-
1060-1070	-	1.330	2.340	1.315	0.291	-
1070-1080	-	2.113	3.016	1.863	0.576	-
1080-1090	-	0.245	2.657	2.250	0.620	-
1090-1100	-	0.205	2.025	1.580	0.241	-
1100-1110	0.838	2.049	1.060	2.700	0.172	-
1110-1120	1.182	2.063	0.907	3.300	0.523	-
1120-1130	1.643	2.326	1.378	0.682	0.320	-
1130-1140	1.190	2.625	0.735	1.191	-	-
1140-1150	0.852	2.480	0.866	3.000	-	-
1150-1160	1.319	0.094	2.268	2.635	-	-
1160-1170	1.529	0.097	1.754	3.300	-	-
1170-1180	1.200	1.134	1.411	-	-	-
1180-1190	2.120	0.991	1.613	-	-	-
1190-1200	1.635	0.296	1.984	-	-	-
1200-1210	1.345	0.738	1.941	-	-	-
1210-1220	0.200	2.190	2.672	-	-	-
1220-1230	-	1.416	-	-	-	-
1230-1240	-	1.223	-	-	-	-
1240-1250	-	1.254	-	-	-	-
1250-1260	-	1.553	-	-	-	-
1260-1270	-	1.406	-	-	-	-
1270-1280	-	0.241	-	-	-	-
1280-1290	-	1.769	-	-	-	-

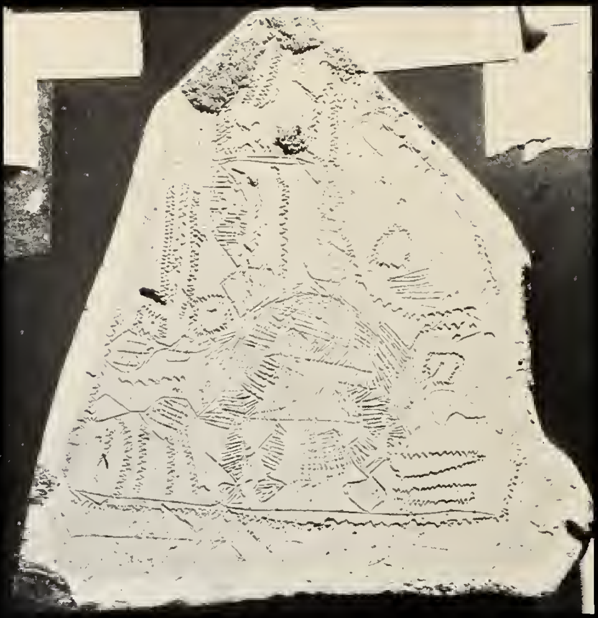
*Lost Core.

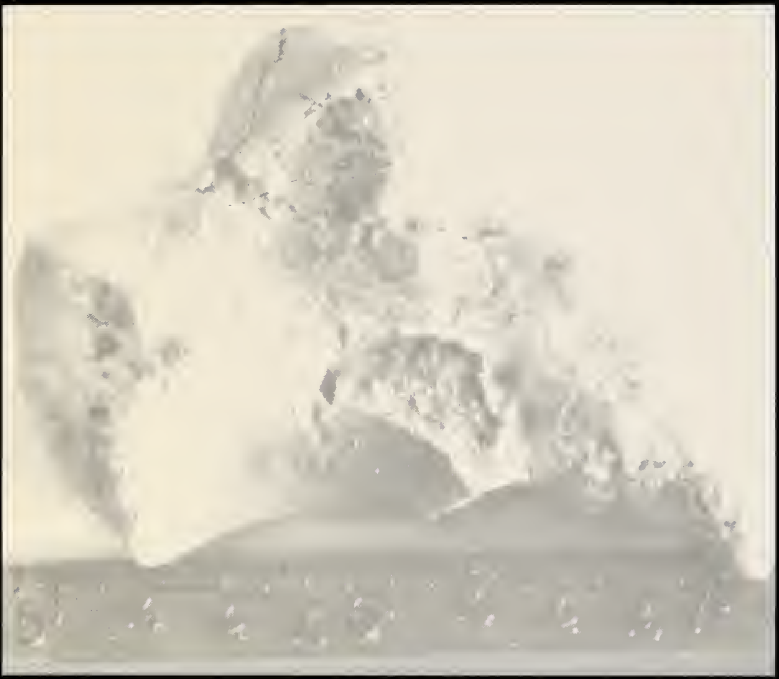
APPENDIX V-4 (Cont.)

Footage Interval	Percent Alumina						
	X-3	X-4	X-5	X-6	X-9	X-10	X-11
330-340	0.704	-	-	-	-	-	-
340-350	0.308	-	-	-	-	-	-
350-360	0.227	-	-	-	-	-	-
360-370	0.873	-	-	-	-	-	-
370-380	0.249	-	-	-	-	-	-
380-390	0.258	-	-	-	-	-	-
390-400	0.954	-	-	-	-	-	-
400-410	0.157	-	-	-	-	-	-
410-420	0.322	-	-	-	-	-	-
420-430	0.145	-	-	-	-	-	-
430-440	0.101	-	-	-	-	-	-
440-450	0.242	-	-	-	-	-	-
450-460	1.012	-	-	-	-	-	-
460-470	1.012	-	-	-	-	-	-
470-480	0.644	-	-	-	-	-	-
480-490	0.179	-	-	-	-	-	-
490-500	0.143	-	-	-	-	-	-
500-510	0.262	-	-	-	-	-	-
510-520	0.210	-	-	-	-	-	-
520-530	0.756	-	-	-	-	-	-
530-540	0.821	-	-	-	-	-	-
540-550	1.400	-	-	0.904	-	-	-
550-560	0.696	-	-	0.570	-	-	-
560-570	1.232	-	-	0.192	-	-	-
570-580	0.977	-	-	0.552	-	-	-
580-590	0.956	-	-	0.300	-	-	-
590-600	-	-	-	0.190	-	-	-
600-610	-	-	-	1.300	-	-	-
610-620	-	-	-	0.300	-	-	-
620-630	-	-	-	0.552	-	-	-
630-640	-	-	-	0.477	-	-	-
640-650	-	-	-	0.313	-	-	-
650-660	-	-	-	0.674	-	-	-
660-670	-	-	-	0.955	-	-	-
670-680	-	-	-	0.812	-	-	-
680-690	-	-	0.686	0.588	-	-	-
690-700	-	-	1.045	0.160	-	-	-
700-710	-	-	0.619	0.090	-	-	-
710-720	-	0.230	0.254	0.174	-	-	-

Footage Interval	Percent Alumina						
	X-3	X-4	X-5	X-6	X-9	X-10	X-11
720-730	-	0.087	1.180	0.223	-	-	-
730-740	-	*	0.246	0.894	-	-	0.815
740-750	-	0.548	0.864	0.228	-	-	0.804
750-760	-	1.800	0.322	1.407	-	-	0.908
760-770	-	0.230	0.195	1.220	-	-	0.704
770-780	-	0.330	0.164	1.180	-	-	0.645
780-790	-	0.086	0.270	1.521	-	-	0.831
790-800	-	0.087	0.591	0.844	-	-	1.470
800-810	-	0.130	0.764	-	-	-	0.220
810-820	-	0.726	0.196	-	0.251	-	0.564
820-830	-	0.260	0.109	-	0.572	-	0.234
830-840	-	0.264	0.619	-	0.300	-	0.282
840-850	-	0.144	0.240	-	0.160	0.818	0.668
850-860	-	0.130	0.590	-	-	0.917	0.557
860-870	-	0.108	0.760	-	-	0.262	0.216
870-880	-	0.186	0.250	-	-	0.740	0.243
880-890	-	0.183	0.994	-	0.113	0.191	0.172
890-900	-	0.312	1.808	-	0.162	0.207	0.197
900-910	-	0.703	1.340	-	0.576	0.259	0.136
910-920	-	0.627	2.700	-	0.287	1.320	0.160
920-930	-	0.617	1.825	-	0.275	0.252	0.199
930-940	-	2.262	-	-	0.217	0.243	0.295
940-950	-	1.018	-	-	0.191	0.193	0.970
950-960	-	-	-	-	0.228	0.836	1.592
960-970	-	-	-	-	0.140	0.206	0.833
970-980	-	-	-	-	0.182	0.180	0.861
980-990	-	-	-	-	0.280	0.176	0.936
990-1000	-	-	-	-	0.290	0.170	-
1000-1010	-	-	-	-	1.205	0.104	-
1010-1020	-	-	-	-	0.807	0.130	-
1020-1030	-	-	-	-	1.204	0.187	-
1030-1040	-	-	-	-	-	0.214	-
1040-1050	-	-	-	-	-	0.825	-
1050-1060	-	-	-	-	-	0.285	-
1060-1070	-	-	-	-	-	0.755	-
1070-1080	-	-	-	-	-	0.258	-
1080-1090	-	-	-	-	-	0.298	-
1090-1100	-	-	-	-	-	1.206	-

*Lost Core





VI
HISTORIC & SCIENTIFIC RESOURCES

VI. HISTORIC AND SCIENTIFIC RESOURCES

The historic and scientific resources program was completed in July 1975 and a final report was submitted to the AOSS for approval. Investigations were conducted to locate and identify significant cultural (historic and prehistoric) and paleontological resources in and around Tracts U-a and U-b to meet the lease stipulations and federal and state antiquities laws. Additional objectives were to provide antiquities clearance for the baseline monitoring sites, as required in the conditions of approval, and to provide a data base for the Detailed Development Plan.

The cultural resources investigations were conducted by Dr. David B. Madsen, Antiquities Section, Utah Historical Society (UHS). The paleontological resource investigations were conducted by Dr. Wade E. Miller, Department of Geology and Zoology, Brigham Young University (BYU). The investigations consisted of on-ground surveys and archival reviews. The study area for these investigations was the lease tracts and a 1.6-km (1-mi) perimeter.

Thirty-six cultural sites and 39 paleontological sites were inventoried and evaluated during the investigations. Reports of the investigations were transmitted to the Area Oil Shale Supervisor's Office in Quarterly Report No. 4. The investigators have submitted their reports to the Bureau of Land Management (Salt Lake City and Vernal, Utah offices) and to the National Park Service, Washington, D.C., as part of their antiquities permit requirements. A summary description of the investigations is provided below. Site location data is omitted from this document to prevent unauthorized collecting from the sites.

A. CULTURAL RESOURCES

1. OBJECTIVES

The objectives of the cultural resources investigation was to locate and evaluate all sites and artifacts in the study area that could provide important or new information concerning the historic and prehistoric inhabitants of the region and to protect these resources from destruction during the project.

2. METHODOLOGY

The methods used in the cultural resources investigation consisted of an on-ground survey, artifact analysis, archival reviews, and contacts with local amateur archeologists. The methods were consistent with current historical and archeological research goals and investigative techniques.

The entire study area was walked and visually inspected by a four-to-five-member field team. The area was traversed by the team, with each person spaced 6 m to 30 m (20 ft to 100 ft) apart and walking in a zigzag pattern except where prevented by topography or vegetation. The field investigation took a total of 67 days during four periods between July 15, 1975, and May 27, 1975.

The sites located were photographed, recorded on standard site-survey forms, and plotted on USGS 7.5 min. series topographic maps. Each prehistoric site was given a number in accordance with the Smithsonian Trinomial System. The historic sites were located by the archeological field crew and visited by the UHS historical subconsultants to evaluate their importance and to collect representative artifacts from the surface for laboratory analysis. The collected artifacts were described, drawn, and compared with published reports of similar artifacts from the Great Basin, Uinta Basin, and Great Plains to identify potential cultural affiliations of the sites. The collected artifacts have been stored with the UHS, and will be available for further research.

Literature describing the history and prehistory of the region and previously recorded site data pertaining to the tracts and the surrounding area were reviewed to assess the results of previous investigations. None of the located historic and prehistoric sites were included on either the National Register of Historic Places or the Utah State Historic Sites Inventory.

Local amateur archeologists were contacted for information regarding unrecorded sites and to examine private artifact collections. An extensive site collection belonging to Mr. Bud Thompson of Bonanza is described in Dr. Madsen's report.

3. SUMMARY OF RESULTS

The 36 cultural sites located during the investigation consist of 10 historic and 32 prehistoric components (six of the prehistoric sites also have historic components). Seven of the sites are situated on the tracts and 27 sites lie within the 1.6-km perimeter. Three sites--42 Un 365, 42 Un 403, and 42 Un 405--are outside the study area.

The study area has generally been isolated from the mainstream of regional historic events. From the first recorded historic contact in 1776 until mineral exploration and development began in the late nineteenth century, no significant historic activities took place in or around the study area. More significant activities occurred in other portions of the Uinta Basin, however. These activities can be divided into four periods: native American, early European exploration and trade, agrarian settlement, and mineral development.

At the time of historic contact, the Uinta Basin was the homeland of the Ute Indians. The Utes subsisted by hunting small game and collecting wild plant foods. Some of the Ute bands to the east and west had acquired horses from the Spanish by this time. These bands had a lifestyle similar to that of the more well-known Plains Indians. The various bands maintained close relations through intermarriage and ceremonial activities.

The arrival of the first Europeans marked the beginning of a series of drastic changes in the Indians' lifestyles. The first European contact was from the south, when Spanish explorers and traders attempted to extend their sphere of influence from Mexico. Reports of trade between the Spaniards and the Utes date back as early as 1712. This trade steadily increased, despite the passage of laws in 1775 forbidding trade with the Utes. The first recorded visit to the area was made by the Escalante expedition in 1776, which intensified the pressure for trading with the Indians (Figure VI-1). It was not until the 1820s, however, that non-native American use of the Uinta Basin intensified, as a result of the influx of French and American fur trappers and traders from the east and south. The first year-round white settlement, Fort Robidoux, was established as a trading post in 1838 and soon became the central meeting point for travelers, traders, and trappers. The trading era ended because of the Mexican war and the declining demand for furs.

The historical event that had the greatest impact in shaping the present economy and culture of the Uinta Basin was the colonization of the area by Mormon settlers in the late nineteenth century. The Mormons did not enter and explore the Uinta Basin until 1861, although the Wasatch Front further west had been settled by the first wave of Mormon settlers 14 years earlier. It soon became apparent that the agrarian settlers and the Utes were in direct competition for the limited resources available along the Wasatch Front. Several skirmishes erupted between settlers and the Ute Indians. Following the Walker War along the Wasatch Front in 1854, the Uinta Reservation was established in the Uinta Basin at the request of the settlers. The Utes refused to move to the reservation, which led to renewed hostilities and eventually to the Black Hawk War (1864 to 1869), in which the Indians were defeated and finally removed to the reservation.

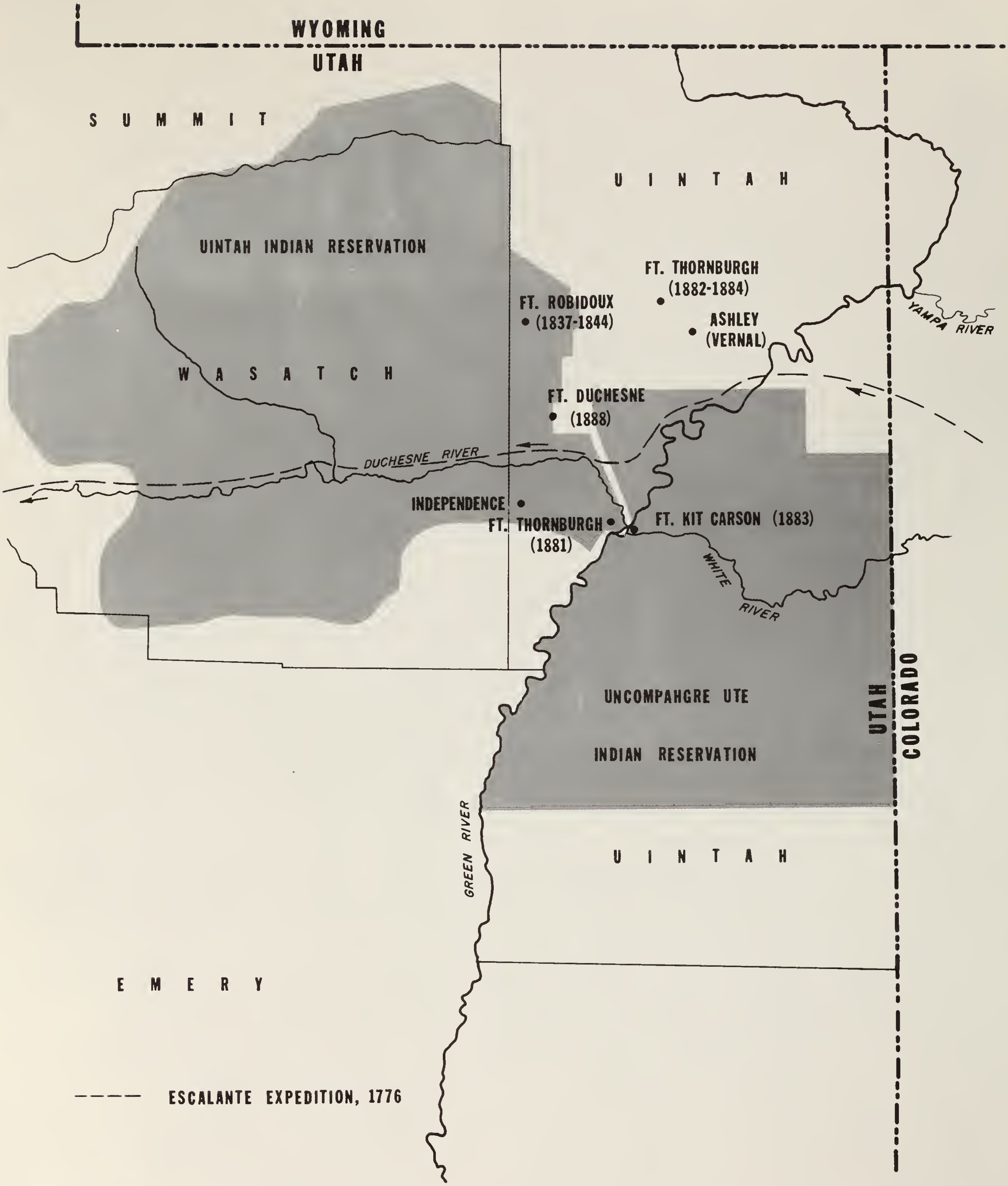
The decade of the 1870s was marked by the establishment of an Ashley Valley settlement, which later became Vernal. Several communities--Naples, Maeser, Jensen, Hallsville--evolved in the surrounding area, and in 1886 a stake of the Church of Jesus Christ of Latter Day Saints was founded in Vernal.

During this period, conflicts between Uncompahgre Utes and white settlers in western Colorado led to their transfer to the Uintah Reservation and the creation in 1881 of the Uncompahgre Reservation. Fort Thornburgh was established to protect the area but was abandoned three years later. Fort Duchesne, founded in 1886, was more successful, eventually becoming a permanent settlement.

The second most important influence on the history of the Uinta Basin was the discovery and exploitation of the area's rich mineral resources. The discovery of gilsonite in the late 1800s led to mounting pressure for opening of the reservation lands to development. Finally, in 1895 the process of allotting 160-acre homesteads to the Utes began so that other parts of the reservation could be opened for mineral development. At the same time the two reservations were combined into what is now known as the Uintah and Ouray Reservation. In 1905 President Roosevelt opened the remainder of the reservation lands for settlement.

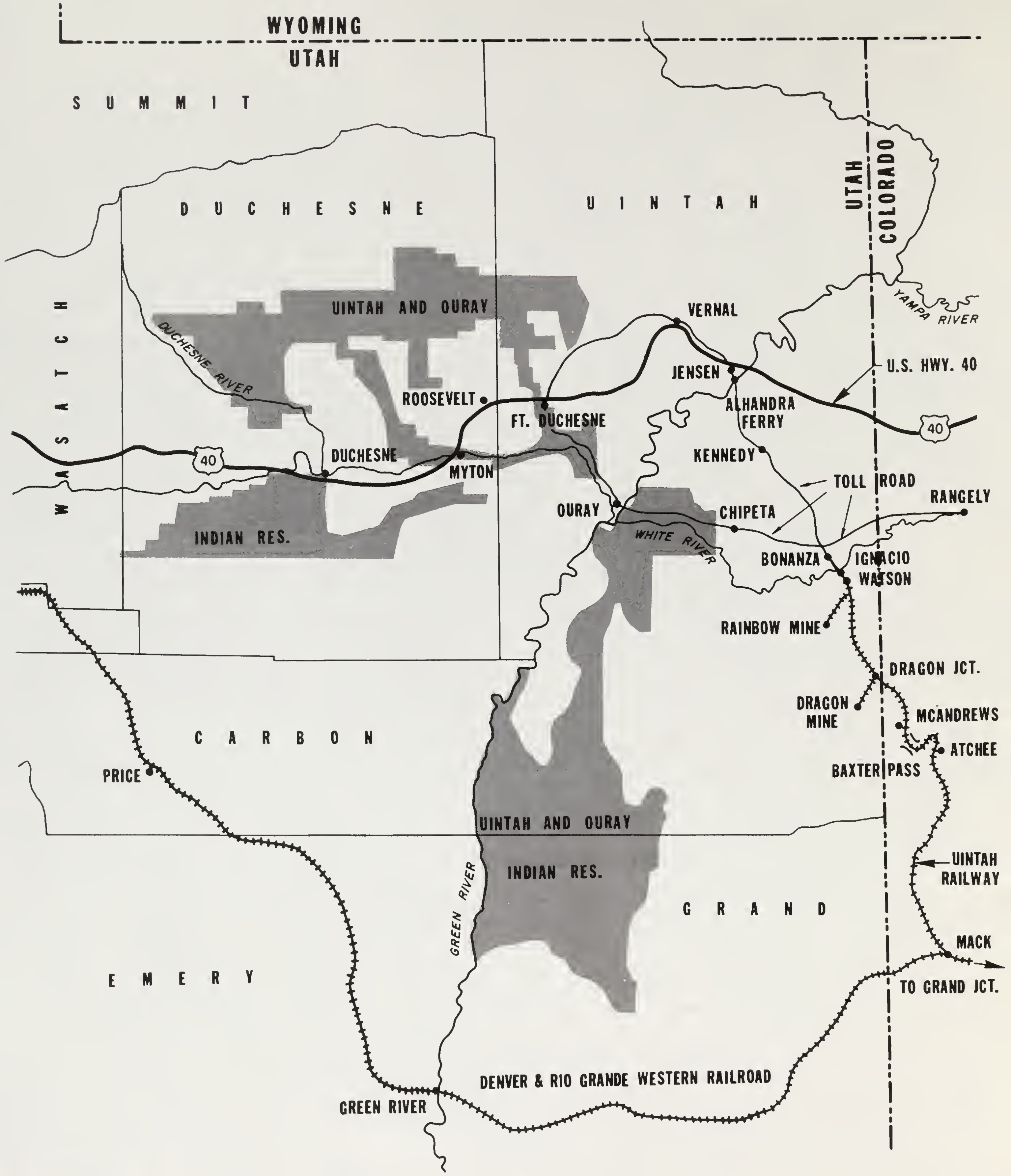
The rapid development of gilsonite mining in the basin and the opening of several small mines in Colorado led to the organization of the Uintah Railway to transport the ore over the Book Cliff Mountains to Mack, Colorado, to connect with the Denver & Rio Grande Western Railroad (Figure VI-2). Following completion of the railroad in 1904, a toll road was built connecting the northern terminus of the railroad at Dragon with Vernal, with a series of stage stops in between.

The opening of the reservation lands precipitated a new wave of settlement. New towns and small farming communities developed, and in 1910 a second stake of the Mormon Church was established at Fort Duchesne. Duchesne County was established in 1915. In 1933 additional land was withdrawn from the Uintah Reservation under the Taylor Grazing Act. In



MAP OF UINTA BASIN BEFORE 1900

FIGURE VI-1



MAP OF UINTA BASIN, 1930'S

FIGURE VI-2

1950, $17,000,000 was awarded to the Uintah and Uncompahgre tribes as compensation for their losses. An additional $7,000,000 was received in 1960. These funds have since been used to support tribal development programs.

Although gilsonite activities in the Uinta Basin had declined by the 1930s (with the exception of the American Gilsonite mine at Bonanza), energy-related development has been of continued importance to the economic development of the area. Oil and gas exploration and production have been major activities since the 1950s, and interest has recently turned to extraction of oil from tar sands and oil shale, especially on Tracts U-a and U-b south of Bonanza. Full-scale commercial development of these resources could signify the beginning of another major period of development in the Uinta Basin.

The historic sites consist of the Ignacio Stage Stop (Figure IV-3), four homestead cabins, and five recent camp sites. The stage stop is the only significant historic site. It is located east of Utah State Highway 45 on the south side of the White River. It was built in 1905 and was the first stop along the Uintah Railway toll road to Vernal, Utah. The remaining structures, now in poor condition, are representative of the architecture of the late frontier period. The homestead cabins were built during the early 1920s and are now dilapidated. None have been occupied by historically important people. The campsites, identified as the recent temporary encampments of sheepherders or hunting parties, are considered historically insignificant by the investigators.

The known prehistoric cultural resources in the region indicate that the Uinta Basin has been occupied by various groups for the last 10,000 years, including Paleo-Indian "Big Game" hunters, Archaic and Basketmaker II hunter-gatherers, Fremont agriculturalists, late prehistoric Northwest Plains hunter-gatherers, and protohistoric Numic (shoshonean linguistic group) hunter-gatherers. Although there have been numerous archeological surveys and excavations, knowledge of these groups is limited in comparison with that of other areas because much of the research was done before the development of the radiocarbon dating technique and other methods of dating artifacts. More recent research has concentrated on only a few of these groups and on limited areas of the Uinta Basin.

The Paleo-Indian cultural tradition is the earliest known recorded human activity in the Uinta Basin. The evidence of this culture consists of two isolated Folsom-type projectile points. The estimated ages of similar points found throughout the western United States have been between

9,000 and 11,000 years old. The evidence of Paleo-Indian occupation of the basin is sparse, probably because the sites have been buried by alluvial deposition.

The Archaic period, lasting from ca. (approximately) 10,000 B.P. (before present) until ca. 2500 B.P., is a temporal designation referring to the earliest hunting and gathering cultures in western North America. The Colorado Plateau Archaic period is believed to have lasted from 8000 B.P. to 3000 B.P. Occupation of the Uinta Basin during the Archaic period is thought to have been between 4200 B. P. and 3300 B.P. Initial settlement in Utah was along the periphery of the Great Salt Lake in the Holocene Epoch, where settlement patterns reflected the fluctuations in lake levels. As the lake gradually receded, fresh water springs were exposed and the area of lake periphery marshes increased, permitting more exploitable flora and fauna resources. The numerous periods of high lake levels during the Holocene Epoch inundated springs and marshes and reduced the availability of halophytic (salt-tolerant) plant species, forcing lacustrine-adapted populations of the Great Basin to migrate to more productive environments in Idaho, Wyoming, and the Colorado Plateau. Faunal remains from representative lakeside sites included mule deer, bison, antelope,and several species of rodents and avifauna. Edible plant remains consisted primarily of marsh and halophytic species. Associated artifacts included the atlatl, flat-slab milling stones, basketry, rabbit nets, rabbit skin robes, stone drills and scrapers, bone awls, and a wide variety of other utilitarian implements.

The earliest dated Archaic components in the Uinta Basin are Thorne Cave (Day 1964) and Deluge Shelter (Leach 1970). Both sites contain Great Basin and Great-Basin derived (McKean) projectile points that have been dated 4200 B. P. and 3800 B.P., respectively. These dates are within the Holocene lake level minima (5500 B.P. to 3500 B.P.), when lacustrine resources were probably quite low.

The date of the earliest Archaic occupation of the Uinta Basin was determined from Thorne Cave. The site itself was apparently occupied for less than 100 years, based on radiocarbon dates of the deposits, but cultural materials recovered from Deluge Shelter indicate that Archaic occupation was much longer. Deluge Shelter contains 15 distinguishable cultural strata separated from one another by either sterile areas or erosional disconformities. Strata 15, 14, and 13 have limited cultural materials, and age and cultural affiliation cannot be determined until radiocarbon dates are available. Strata 12 through 8 comprise the Archaic component of the site. The three radiocarbon samples from this component are 3630±85 B.P. (stratum 12), 3840±210 B.P. (stratum 11), and 3260±120 B.P. (stratum 8).

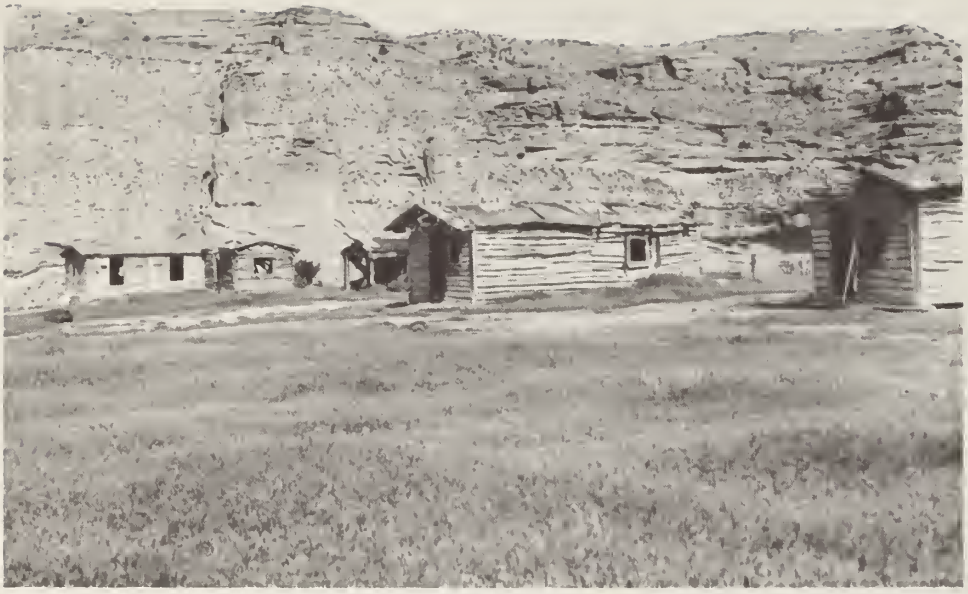


FIGURE VI-3 IGNACIO STAGE STOP

The Archaic populations are believed to have abandoned the Colorado Plateau by 3000 B.P., leaving the entire eastern Great Basin unoccupied until the influx ca. 1250 B.P. of Fremont agriculturalists (Madsen and Berry 1975). There is no evidence of cultural continuity between Archaic and Fremont cultures. It is thought that by ca. 1600 B.P., groups functioning at a Basketmaker II level of technology occupied the Colorado Plateau from the Four Corners area to the Uinta Basin, and that Fremont cultures developed from this early agricultural substratum, as evidenced by cultural materials from strata 6 and 5 of the Deluge Shelter.

The Fremont agriculturalists in Utah were aboriginal farming groups who settled north of the Anasazi area. The earliest recorded sites on the Colorado Plateau are dated ca. 1350 B.P. Fremont occupation of Utah ended by ca. 650 B.P. Based on Pecos classification criteria, technological advancements of materials collected from Fremont sites fall within the Basketmaker III-Pueblo I range.

Uinta Fremont sites are typically small settlements consisting of one to five shallow pit structures. Freestanding storage granaries are absent. Sites are usually located on knolls, buttes, or hill slopes above flood plains. Calcite-tempered Uinta Gray is the predominant (99 percent) pottery type. Both corner-notched and side-notched projectile points have been recovered. The corner-notched varieties resemble Late Woodlands (Johnson 1974) and Uncompahgre Complex points (Wormington and Lister 1956). The side-notched varieties are identical to Plains Side-Notched (Kehoe 1966).

Uinta Fremont subsistence was apparently based on corn agriculture supplemented by hunting and gathering (Marwitt 1970). This is inferred from the charred corn remains recovered from village sites and the numerous "temporary use" sites (small open encampments and cave/rockshelters) in adjacent ecozones.

Excavated Uinta Fremont components include Caldwell Village (Ambler 1966a, 1966b), Boundary Village (Leach 1966b), Whiterocks Village, the Goodrich Site, Felter Hill, Flat Top Butte (all in Shields 1967), Wholeplace Village, Wagon Run, Fremont Playhouse, the MacLeod Site, Burnt Horse Village, the Dam Site, Cub Creek Village, and the Ford Site (all in Breternitz 1970). In addition, Hell's Midden (Lister 1951), Mantle's Cave (Burgh and Scoggin 1948), Marigold's Cave (Burgh 1950; Dick n.d.), and Deluge Shelter (Leach 1970) contained Fremont components. This impressive number of excavations has unfortunately produced only a handful of radiocarbon determinations and a single tree-ring date. Ten of the 11 radiocarbon dates range from 1450 B.P. to 850 B.P. The tree-ring date from Marigold's Cave (Burgh 1950) is ca. 1200 B.P.

The length of Uinta Basin occupation by the protohistoric Numic hunter-gatherers is unknown. The distinctive Paiute-Shoshoni pottery associated with the Ute has been found on the surface of numerous sites but has not been recovered in a stratified context.

The sites located during the investigation were so disturbed, that it was possible to make only tentative identifications of the prehistoric inhabitants in the study area. Most of the sites showed evidence of unauthorized artifact collecting in the form of surface collecting and digging, both of which disturb potential functional and chronological information that may be obtained during a surface investigation. Interpretations were therefore limited only to establishing the presence or absence of some of the previously-mentioned prehistoric cultures. Descriptions of the prehistoric sites are presented in Table VI-1.

The Thompson collection (site 42 Un 377) unequivocally establishes the presence of Archaic hunter-gatherers in the area. The presence of McKean points (Figure VI-4) suggests that initial occupation in the study area occurred between 4800 B.P. and 3300 B.P. Subsistence activities apparently centered around hunting, as indicated by the charred bone refuse unearthed at the site. The virtual absence of milling stones at 42 Un 377 and, for that matter, at most of the recorded sites suggests that floral resources were not extensively exploited at the riverine encampments.

The cultural affiliation of the remainder of the sites is difficult to assess. The small projectile points (Figure VI-5) from sites 42 Un 365, 42 Un 367, 42 Un 370, 42 Un 376, 42 Un 377, 42 Un 379 and 42 Un 405 indicate the use of the bow and arrow. The corner-notched varieties are similar to types associated with northwest Plains hunter-gatherers (Kehoe 1966), eastern Plains agriculturalists (Johnson 1974), the Uncompahgre Complex (Wormington and Lister 1956), Pueblo I in the Anasazi area (Brew 1946), and various Fremont complexes (Marwitt 1970). This indicates a temporal range of 1450 B.P. to 850 B.P. The side-notched types replaced the corner-notched points on the northwest Plains (Kehoe 1966) and are associated with Pueblo II and III complexes in the Anasazi area (Morris 1939; Brew 1946). Their distribution in the Fremont area is restricted to the Great Salt Lake and Uinta variants. The temporal range in the study area is probably 1000 B.P. to 650 B.P. Of these various cultures, only the northwest Plains and Uncompahgre were aceramic (lacking pottery), and therefore the absence of pottery at sites yielding the small points suggests Plains or Uncompahgre affiliation. The only evidence of Anasazi cultures in the study area is the Tusayan Corrugated pottery recovered from site 42 Un 401. Mesa Verde ceramics have been reported

TABLE VI-1

DESCRIPTION OF THE PREHISTORIC SITES

Site Number	Site Type	On Tracts	Cultural Affiliations	Cultural Materials
42 Un 118*	Rock Shelter		?	chipping debris, mat fragments, corn cobs, burned bone
324	Rock Shelter	X	?	point fragment, chipping debris, bone, charcoal, trash deposits
355*	Rock Shelter		Archaic	point fragment, utilized flakes, chipping debris
356*	Open		?	worked flakes, chipping debris
357*	Open		Archaic	projectile point, chipping debris
358*	Open		Late Prehistoric Numic?	projectile point
365*	Rock Shelter		Late Prehistoric Historic	projectile point, possible granary, historic trash
366*	Rock Shelter		Archaic?	biface, projectile point, chipping debris, pictograph, charcoal, burned bone
367*	Rock Shelter		Late Prehistoric Archaic?	various projectile points, bifaces, utilized flakes, cores
368*	Open		Archaic?	bifaces, utilized flakes
369*	Open		Archaic?	bifaces, worked flakes, chipping debris
370*	Open		Archaic?	projectile point, bifaces, utilized flakes, hammerstones, fire-blackened cobbles
371*	Open		Late Prehistoric	etched stone tablet, utilized flake
372	Open	X	Archaic?	biface, utilized flakes
373*	Open	X	Archaic?	utilized flakes, fire-cracked river cobbles, chipping debris
374*	Open		Archaic?	biface, utilized flake, fire-cracked cobbles
375*	Open		Archaic?	point fragment, biface, utilized flakes
376*	Open		Archaic?	projectile points, utilized flakes, chipping debris
377*	Open		Late Prehistoric Archaic?	point fragment, biface, utilized flakes, Thompson artifact collection
378*	Open		Archaic?	biface, utilized flakes, chipping debris
379*	Open		? Historic	projectile point, utilized flakes, chipping debris, Tipi Ring(?), historic trash

TABLE VI-1 (Cont.)

Site Number	Site Type	On Tracts	Cultural Affiliations	Cultural Materials
42 Un 380*	Open		Archaic	projectile point
381*	Rock Shelter		?	fire-blackened cobbles, charcoal
401*	Open		Late Prehistoric Historic	pot sherds, mano, metate, hammerstone, bifaces, utilized flakes, chipping debris, Ignacio Stage Stop
402*	Rock Shelter		?	bifaces, utilized flakes, cores, flakes cobbles
403*	Isolated pictographs		?	prehistoric pictographs, historic marks
404*	Rock Shelter		?	projectile point
405*	Open		Plains?	structures(?), fire pits(?), steatite pipe, hammerstone, projectile points, drill, bifaces, utilized flakes
406*	Open	X	? Historic	biface, flaked cobbles, historic trash
407	Rock Shelter	X	?	biface, utilized flakes, chipping debris
408	Open	X	?	
409*	Rock Shelter	X	? Historic -	bifaces, utilized flakes, hammerstone, historic encampment

NOTES: Historic components, except 401, Ignacio Stage Stop, consist of trash from recent sheepherder or hunter camps.

*indicates potentially significant sites.

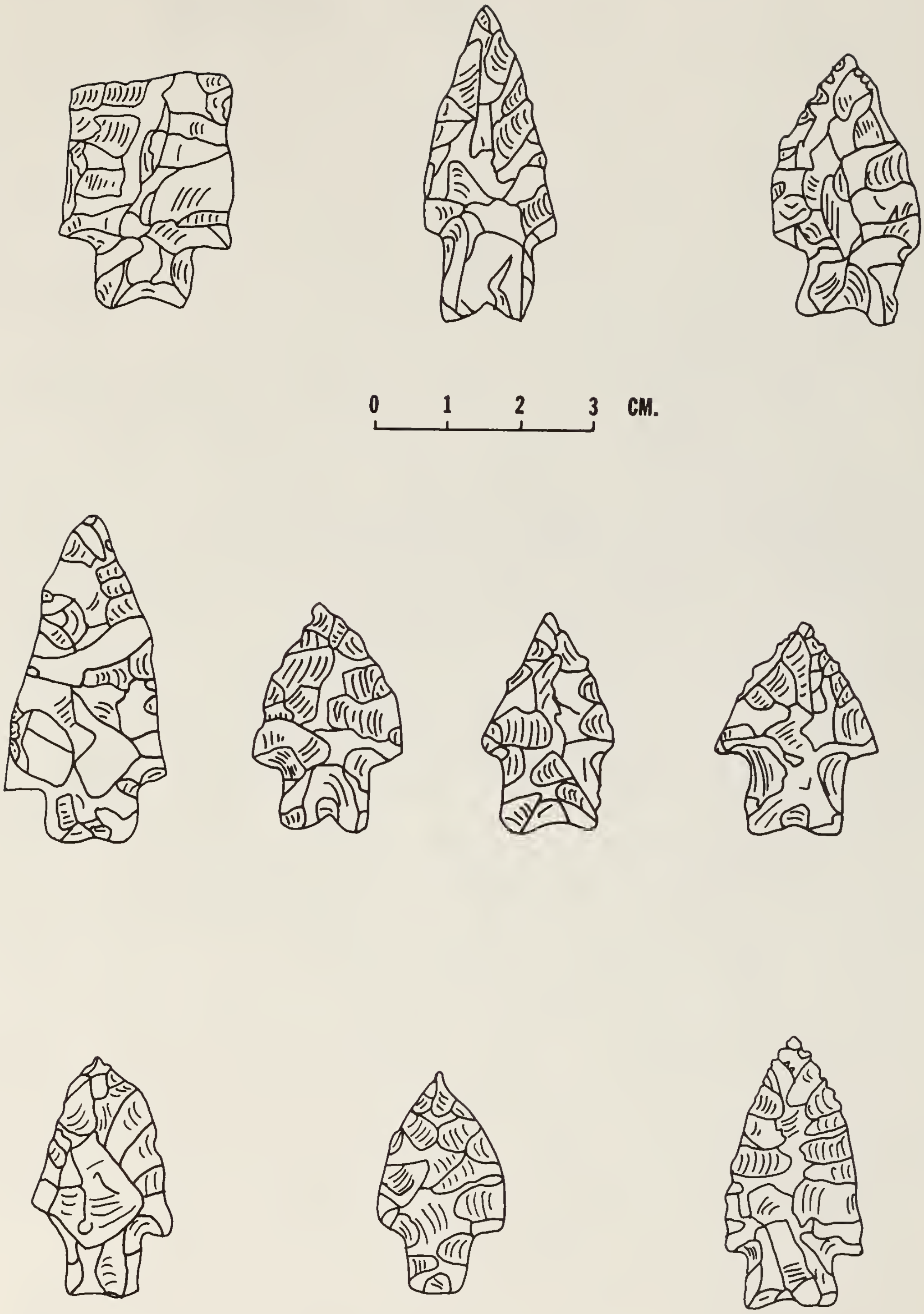
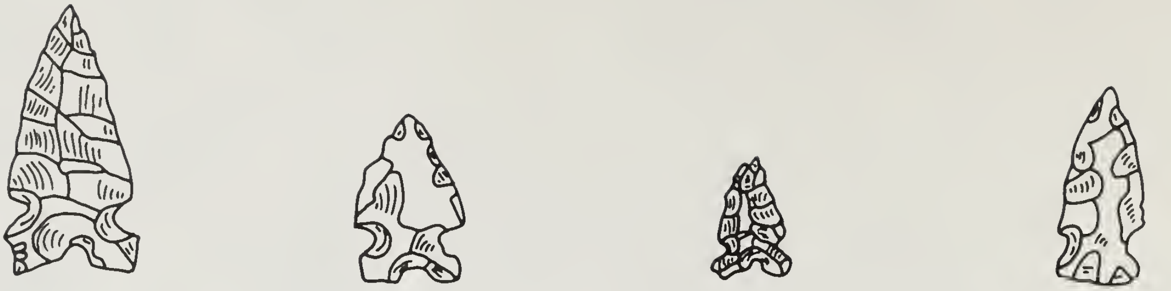
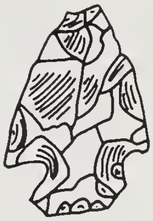


FIGURE VI-4 MC KEAN PROJECTILE POINTS



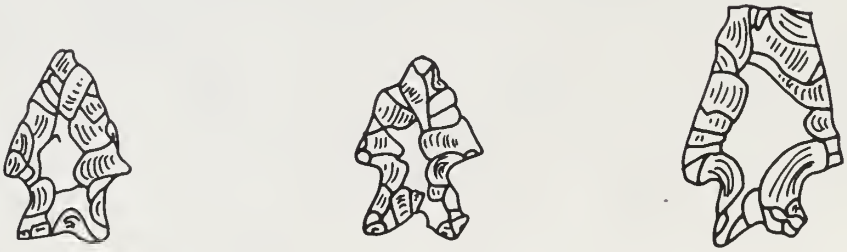
42 UN 365 42 UN 405 42 UN 376 42 UN 405

SIDE-NOTCHED



42 UN 367

CORNER-NOTCHED



42 UN 370 42 UN 379 42 UN 376

STEMMED

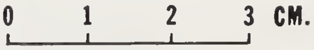


FIGURE VI-5 SMALL PROJECTILE POINT SERIES

by Breternitz (1970) at Dinosaur National Monument, but this is the first reported occurrence of Kayenta series ceramics in the Uinta Basin. Breternitz interprets the Mesa Verdean ceramics as "trade ware" rather than as an indication of Anasazi occupation. The same interpretation is probably appropriate here, although it is also possible that the Kayenta sherds were transported to the site by white travelers.

Sites 42 Un 118 and 42 Un 366 are potentially relevant to the Basketmaker II hypothesis offered earlier. The Basketmaker II level of technology is defined as the absence of ceramics, use of atlatl, and the cultivation of maize. Site 42 Un 118 has yielded numerous corn cobs but no pottery. No pottery was recovered from 42 Un 366, and the red ochre pictographs are quite similar to those associated with Basketmaker II sites in northeastern Arizona. Neither site yielded diagnostic lithic material. The Basketmaker II assignation is admittedly conjectural, and controlled excavation will be required to support or refute this claim.

No definite evidence of Fremont occupance was found in the survey area. The only examples of Uinta Gray pottery have been found a few miles east of the study area. This indicates that, contrary to published opinion, Fremont agriculturalists may not have been the predominant cultural entity in the Uinta Basin during the late (post 1500 B.P.) prehistoric period. The same conclusion is suggested by the Dinosaur National Monument data (Breternitz 1970), since only about 5 percent of the sites contained Fremont pottery types.

Rock art located during the investigation consists of pictographs, petroglyphs, and an etched stone tablet. Site 42 Un 366 has three pictographs and two petroglyphs. The pictographs are painted designs (red ochre) of a "horned Fremont" figure, a snakelike figure, and one unidentified figure. The petroglyphs are pecked or incised horse and mountain-sheep designs. Site 42 Un 403 is a big-horn sheep petroglyph (Figure VI-6). The etched stone tablet (Figure VI-7) was found at 42 Un 371. The designs on the tablet are geometric and anthropomorphic.

The cultural affiliations of the rock art are difficult to determine for two reasons. Previous investigators (Gunnerson 1957, 1969; Morss 1931; Schaafsma 1971; Sharrock 1966) have identified similar designs as Fremont; however, these designs also occur in Montana and Arizona, where there is no evidence of Fremont occupation. Rock art can rarely be associated with a particular culture, since they usually do not occur in a stratified or datable context. Further academic research is needed to establish the cultural affiliations and purposes of these and other Uinta Basin rock art designs.

4. CONCLUSIONS

The results of the cultural resources investigation show that the study area was occupied from approximately 4,800 years ago until recent times. There is no evidence of earlier cultures and little evidence for some of the cultures thought to have occupied the area during this period.

The only significant historical site is the Ignacio Stage Stop. It is being nominated by the Utah Historical Society to the National Register of Historic Places and will be included in the Utah State Register of Historic Places.

5. WORK SCHEDULED

No further work is scheduled for cultural resources as part of the environmental baseline monitoring program. White River Shale Project will conduct any further work necessary, which will probably consist of test excavations of the on-tract prehistoric sites and implementation of any mitigation measures needed prior to construction.

Because of the disturbance found at most of the sites, their significance could not be firmly established, and therefore they are not being nominated to national or state historic site registers at this time. The potentially significant sites are indicated in Table VI-1.

B. PALEONTOLOGICAL RESOURCES

1. OBJECTIVES

The objectives of the paleontological resources investigation were to determine the types, locations, and abundance of fossil, floral, and faunal remains in the study area and to evaluate their scientific value so that these resources can be protected during the project.

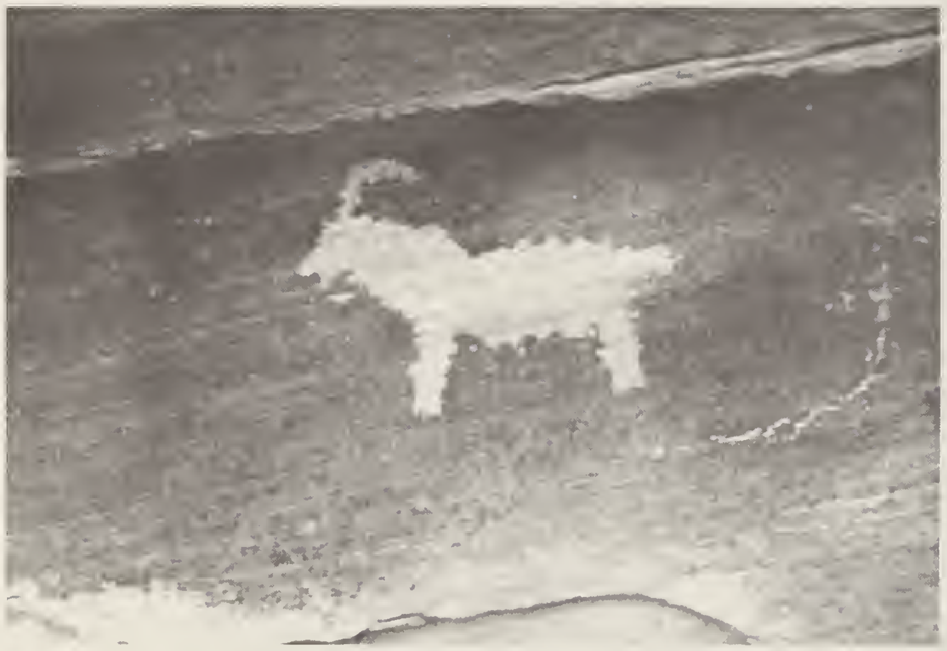
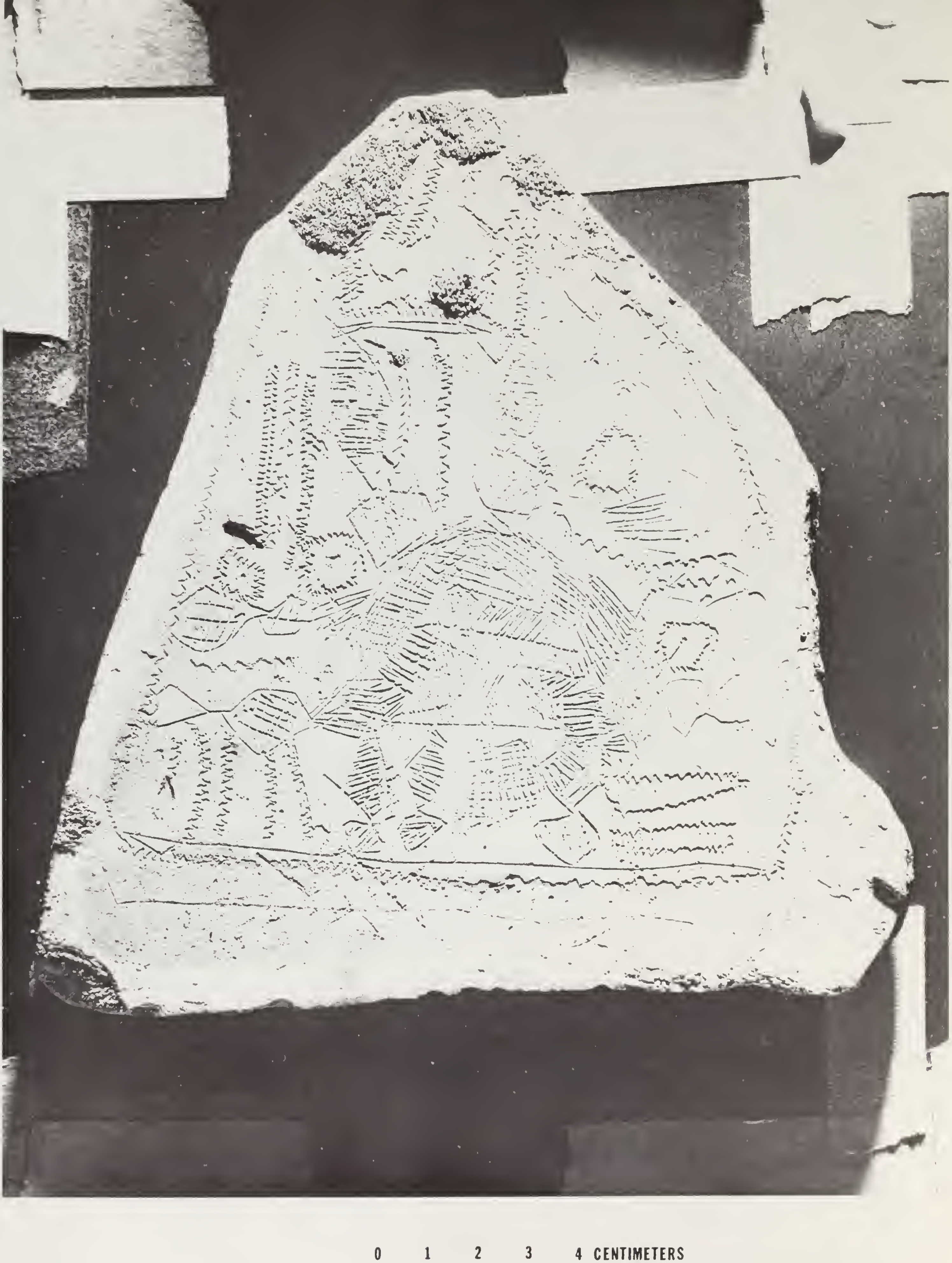


FIGURE VI-6 BIG HORN PETROGLYPH (42 UN 403)



0 1 2 3 4 CENTIMETERS

FIGURE VI-7 ETCHED STONE TABLET (42UN371).

2. METHODOLOGY

The paleontological investigation consisted of archival reviews, a field survey, and fossil identification. All field-work was conducted by Dr. Miller and qualified graduate and undergraduate students. Dr. Stephen Wood, an entomologist with BYU, was consulted to identify the fossil insect specimens.

Before the field survey began, regional paleontological and geological materials were reviewed to determine potentially fossiliferous areas. The material included geological reports and maps and paleontological literature pertaining to the Uinta Basin.

The fieldwork consisted of two activities--a preliminary inspection of the study area and the full field survey. The site was first inspected to determine the logistical requirements for the field survey. The field survey consisted of inspections of the baseline monitoring sites, the new access roads, and the rest of the study area, section by section. The entire study area was walked and visually examined, with particular attention given to outcrops of geologic formations. The fieldwork was conducted between July 1974 and May 1975.

The sites located were plotted on USGS 7.5 min. topographic maps. The types and the condition of the fossil's geologic formation and the locational data were recorded and photographs were taken. Each fossil locality was given a field number.

Fossils that could not be identified in the field were removed and taken to BYU for inspection. Each specimen was removed from its sandstone matrix and identified by comparison with descriptions of previously collected specimens. These specimens are stored at BYU pending any further work. Dr. Wood accompanied Dr. Miller to the study area to inspect the located fossil insect sites. Dr. Wood identified the insect types and determined the state of preservation and the scientific value of the fossil specimens.

3. SUMMARY OF RESULTS

A number of geological formations in the Uinta Basin contain important paleontological resources. One of the most famous Mesozoic formations in the region is the Morrison Formation. It is well exposed at the southern base of the Uinta Mountains, especially along the eastern extent, and probably underlies the Uinta Basin. Most of the dinosaurs from North America have been recovered from the Jurassic Morrison Formation. Fossil dinosaurs from this formation can be seen at Dinosaur National Monument.

The numerous Cretaceous strata overlying the Morrison Formation are extensively exposed in surrounding uplifted structures and also underlie the basin. During the Cretaceous time the sea invaded much of the eastern part of Utah, as evidenced by the numerous sea fossils dating from that period. These fossils, extremely abundant in some of the Cretaceous strata, include a variety of molluscs, trace fossils, foraminifera, bony fish, sharks, and marine reptiles. Some of the Cretaceous rocks represent terrestrial conditions, having yielded fossils of land plants, some invertebrates, and a variety of reptiles, including dinosaurs. Even fossilized shells of dinosaur eggs have been found.

The earliest Tertiary rocks underlying the exposed Eocene deposits in the Uinta Basin also contain non-marine fossils, indicating continental and fresh-water lake environments. Fossils recovered include various plants, several types of invertebrates (especially molluscs and ostracodes), fish, aquatic reptiles (turtles, champsosaurs, and crocodiles), terrestrial reptiles (mostly tortoises and lizards), birds, and mammals.

Most of the exposed strata in the Uinta Basin consist of alluvial (stream-related) and lacustrine (lake) deposits. In order of descending age the primary formations involved are the Green, Uinta, and Duchesne Formations. These formations have yielded abundant fossils in many areas within the Uinta Basin. Excellent specimens representing plants, invertebrates, and vertebrates have been collected over the past 100 years. Plant fossils are mostly pollen, petrified wood, and leaf imprints of angiosperms (flowering plants); significant specimens of lower plant types, including algae, have also been recovered. Invertebrate fossils collected are mostly fresh-water molluscs, ostracodes, and insects. The vertebrate fossils are especially numerous and varied. Included are fresh-water fish, reptiles (especially turtles, tortoises, and crocodiles), birds, and many mammals. The types of mammals found in the Uinta Basin are all extinct, but some have left living descendents belonging to the same taxonomic family. Identified fossil mammals from the basin include marsupials, insectivores, primates, tillodonts, taeniodonts, rabbits, rodents, creodonts, carnivores (including one type larger than the African lion), condylarths, uintatheres, a wide variety of brontotheres (titanotheres), ancestral horses (lamb-sized animals), rhinoceroses, oreodonts, ancestral camels, and other artiodactyls.

Over 100 years ago, F.V. Hayden, a chief geologist for the United States Geological Survey, studied the Uinta Mountains and the Uinta Basin. Although he was not primarily a paleontologist, he understood the value of fossils and had the more important ones shipped to the leading paleontologists of his time. His reports of the area soon attracted several paleontologists, who did much of the early detailed geology. Some work on fossil plants was done in the late 1800s. Perhaps the most significant studies were those of Knowlton (1923) and MacGinitie (1969). Fossil insects of the area were also studied in the latter part of the last century, mostly by Scudder (1877, 1890, 1892). Although there has been some recent research on these insects, much more remains to be done (Carpenter 1955).

The most notable fossils from the Uinta Basin are vertebrates. These were first studied in the 1880s by the then most eminent vertebrate paleontologists of North America and probably of the world, including O.C. Marsh, E.D. Cope, W.B. Scott, and H.F. Osborn. These men are reported to have come by rail from the East to the Uinta Basin and from there by horse and wagon to the collecting sites. Another generation of paleontologists worked the area in the early 1900s. Since that time, only a few paleontologists have worked in the Uinta Basin.

Dr. Miller's work in various locations of the Uinta Basin indicates a need for additional academic research. Earlier surveyors were not usually careful in recording exact topographic and stratigraphic positions of the recovered fossils; therefore, recovery of fossils is needed to establish precise chronological relationships of the enclosing strata. Also, more complete specimens of a number of animal types are needed for further study. Uintatheres, for example, are known only from Wyoming, Colorado, Utah, and Asian Mongolia. Only a few specimens are known in Utah and these are from the Uinta Basin.

Fossils were discovered in most of the project area in both the Green River and Uinta formations of the Eocene Epoch. Leaves, petrified wood, insect fossils, and fish fossils were found in the Green River Formation. Fossils of petrified wood, turtle bone and shell, crocodile, and brontothere were found in the Uinta Formation. The fossil types and formations are listed in Table VI-2.

The concentration of fossils in the paleontological sites ranges from dense to sparse, and the state of perservation ranges from poor to excellent. A description of each paleontological site is contained in Table VI-3. Eighteen of the 39 sites are on the tracts and three sites (12, 19, and 32) are outside the study area.

TABLE VI-2

FOSSIL TYPES LOCATED DURING THE PALEONTOLOGICAL INVESTIGATION

Common Name	Genus or Family Name	Formation of Occurrence	
		Middle Eocene Green River Fm.	Late Ecoene Uinta Fm.
PLANTS:			
Laurel	Umbellularia	X	
Poplar	Populus	X	
Willow	Salix	X	
Sycamore	Platanus	X	
INVERTEBRATES:			
March Flies	Bibionidae	X	
Flower Flies	Syraphidae	X	
Common Fly	Musca	X	
Bot Fly	Lithohypoderma	X	
Bot Fly	Hypoderma	X	
Soldier Fly	Lithophysa	X	
Crane Fly	Tipula	X	
Dragonfly	Sympetrum	X	
VERTEBRATES:			
Gar Pike	Lepidosteus	X	
Alligator	Allognathosuchus		X
Brontothere (large extinct mammal)	Paleosyops		X
"	Eotitanops		X
"	Telmatherium		X
"	Dolichorhinus		X
"	Metarhinus		X

TABLE VI-3

DESCRIPTION OF THE PALEONTOLOGICAL SITES

Site Number	Fossil Types	Geological Formations	On Tract
1	Unidentifiable plant debris	Uinta	X
2	" " "	"	X
3	Fragmental plan remains	Green River	X
4	Unidentifiable plant debris	Lower Uinta, Upper Green River	X
5*	Fragmental plans, some complete leaves	Green River	X
6	Unidentifiable plant debris	Lower Uinta, Upper Green River	X
7*	Insects, leaves	Green River	
8*	Fragmental plants, some complete leaves	" "	X
9*	Fish scales, leaves	" "	X
10	Unidentifiable wood fragments	Uinta	
11*	Insects	Green River	
12*	"	" "	
13	Wood fragments	Uinta	
14*	Insects, plant fragments, some leaves	Green River	
15 a,b,c*	Insects, plant fragments	" "	
16*	Insects, plant fragments, seeds	" "	
17*	Insects	" "	
18*	Plant fragments, some complete leaves	Uinta	

TABLE VI-3 (Cont.)

Site Number	Fossil Types	Geological Formations	On Tract
19*	Plant fragments, some complete leaves	Lower Uinta, Upper Green River	
20*	Turtle shell & bone, plant fragments	Uinta	X
21	Some petrified wood	"	
22*	Brontothere bones, turtle shell	"	
23	Turtle shell fragments, wood	Uinta	X
24*	Brontothere teeth, turtle shell	"	X
25	Petrified wood	"	
26*	Brontothere teeth, turtle shell fragments	"	
27	Petrified wood	"	
28*	Brontothere bone, petrified wood	"	X
29	Petrified wood	"	X
30	Turtle shell fragments	"	X
31*	Brontothere teeth & bones	"	
32	Unidentifiable bone fragments	"	X
33	Petrified wood	"	
34	Fish scales	Green River	X
35	Wood fragments	Uinta	X
36	" "	"	X

TABLE VI-3 (Cont.)

Site Number	Fossil Types	Geological Formations	On Tract
37	Fragmental plants, some complete leaves	Uinta	
38	Fragmental plants, some complete leaves	"	
39*	Brontothere teeth & bones, alligator teeth, turtle shell	"	

*Significant site

The plant fossils most easily identified were angiosperm (flowering plant) leaves (Figure VI-8). The leaf fossils consisted of carbonized compressions and a few imprints. Petrified wood occurs throughout the study area, but generic identification was generally not possible.

The best represented insect fossils are from the order Diptera (Figure VI-9). Six families--Bibionidae, Syraphidae, Muscidae, Stratiomyidae, Oestridae, and Tupulidae--were identified. Of these families, the only generic identifications possible were Musca (common fly), Hypoderma and Lithohypderma (bot flies), Lithophysa (soldier fly), and Tipula (crane fly), all from the last four families. Fossil insects from the other three orders were poorly preserved. Most of the fossil insects were larval forms.

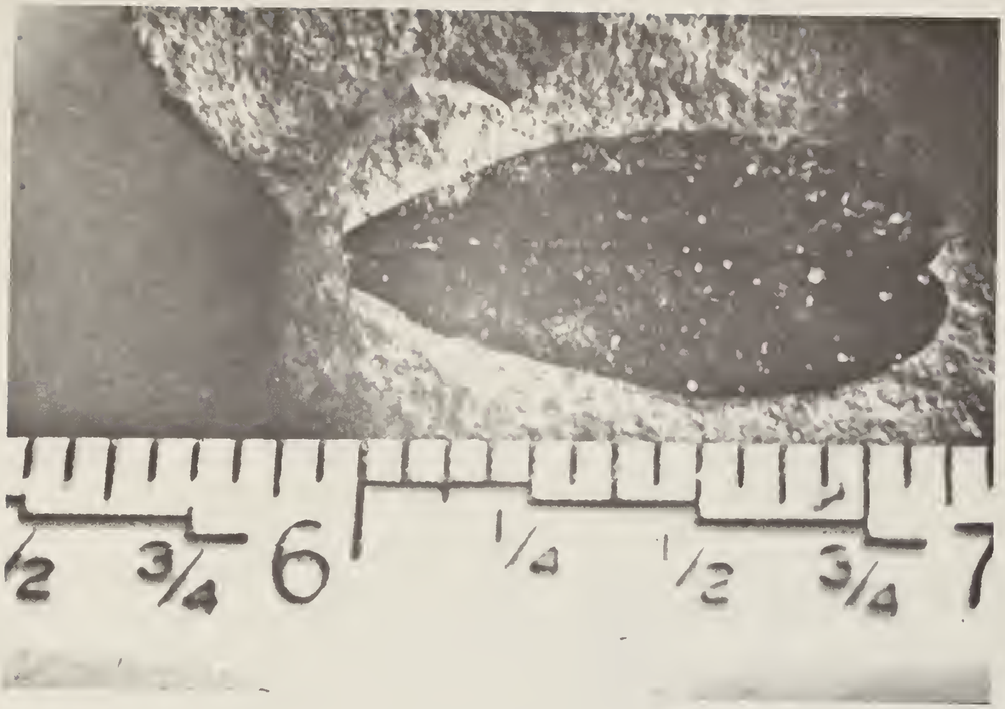
The only fossil fish were scales identified as Lepidosteus (gar pike). Bone fragments were found but were not identifiable.

Reptilian fossils are represented by Allognathosuchus (crocodile) and various turtle bone and shell fragments that could not be identified.

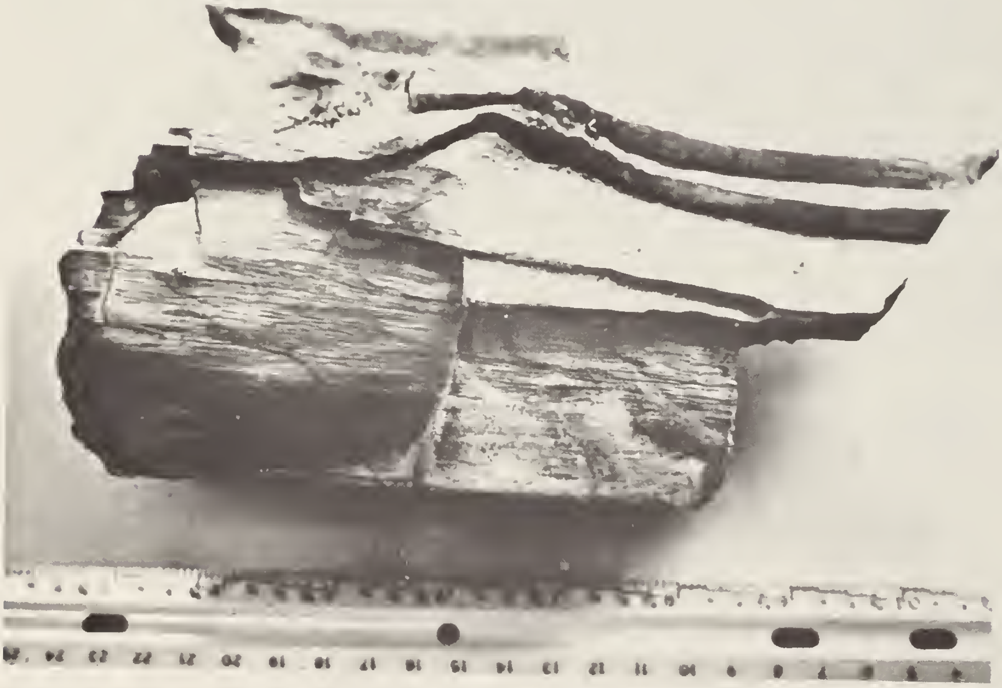
The only mammalian fossils discovered were five genera of brontothere (order Perrissodactyla) large mammals (now extinct) that are toxonomically related to the horse and the rhinocerous (Figure IV-10). These included Paleosyops, Eotitanops, Telematherium, Dolichorimus, and Metharhinus. Some unidentified bone fragments may belong to a similar mammal type known as a uintathere (order Dioncerata). Although not located during this investigation, other mammal fossils may be found in subsurface deposits.

4. CONCLUSIONS

All fossils are significant, but to differing degrees. Plant fossils are useful only as general indicators of geologic time and as significant indicators of past climatic conditions. This has been true for plant fossils from the Uinta Basin, especially those from the Green River Formation. Invertebrate fossils are usually better time indicators than plant fossils and are also useful in interpreting paleoenvironments. Vertebrate fossils, especially those of mammals, are very important as time indicators. They are also useful in determining past climatic and environmental conditions for a given time and place. Mammal fossils have been important in determining that the Green River Formation is a series of lake beds and the Uinta Formation is primarily stream deposits.

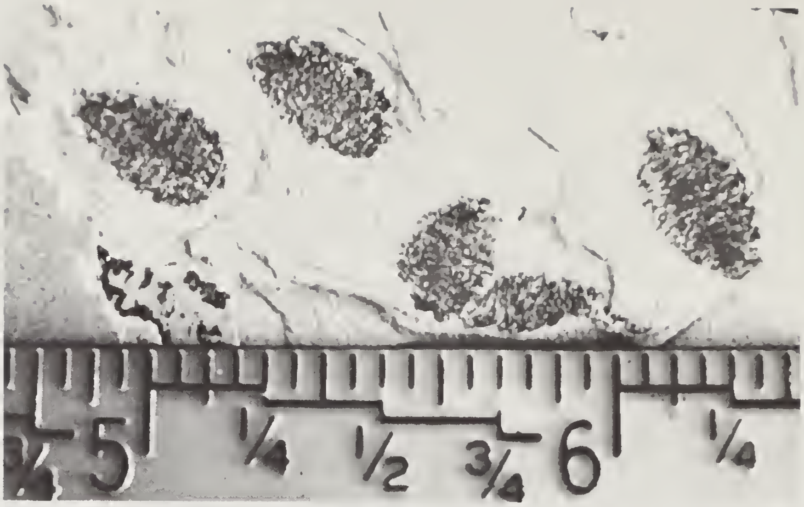


ELM LEAF

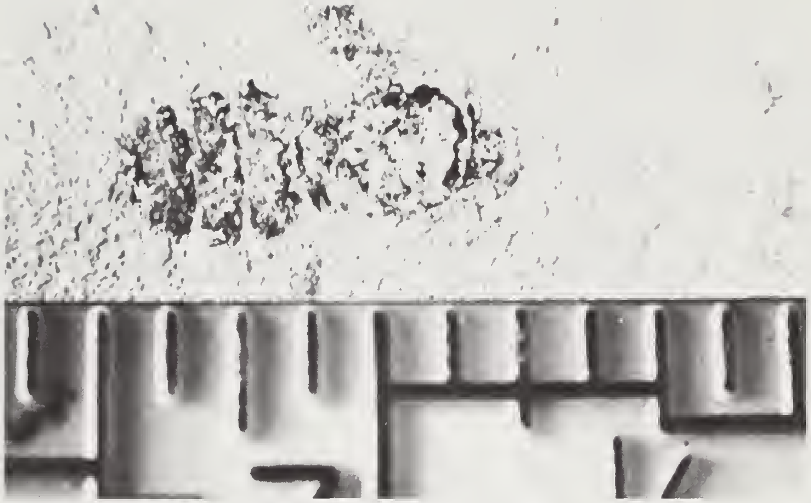


PETRIFIED WOOD, SPECIES INDETERMINATE

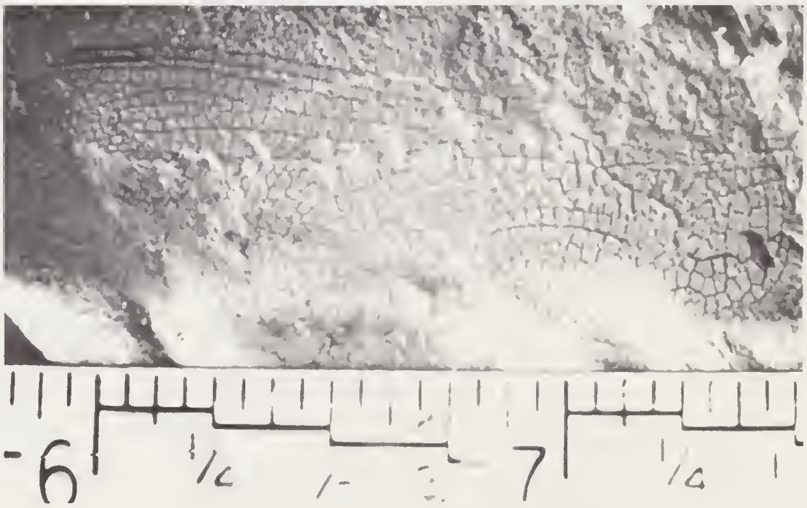
FIGURE VI-8 FOSSIL PLANTS



LARVAL FLIES, HYODERMA

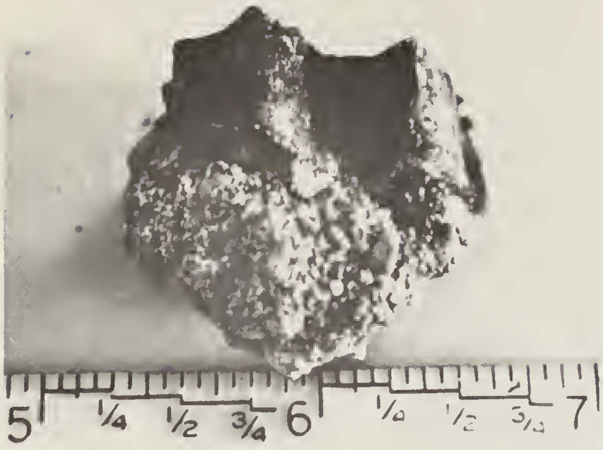


ADULT FLY, LITHOPHYSA



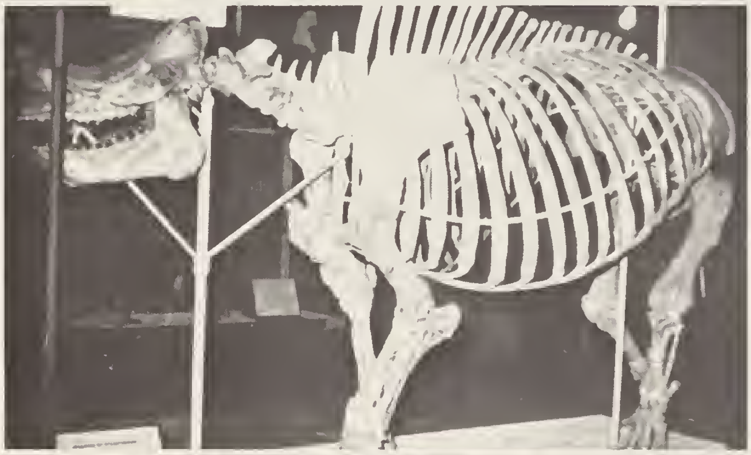
DRAGON FLY WING, DYSAGRION OR SYMETRON

FIGURE VI-9 FOSSIL INSECTS

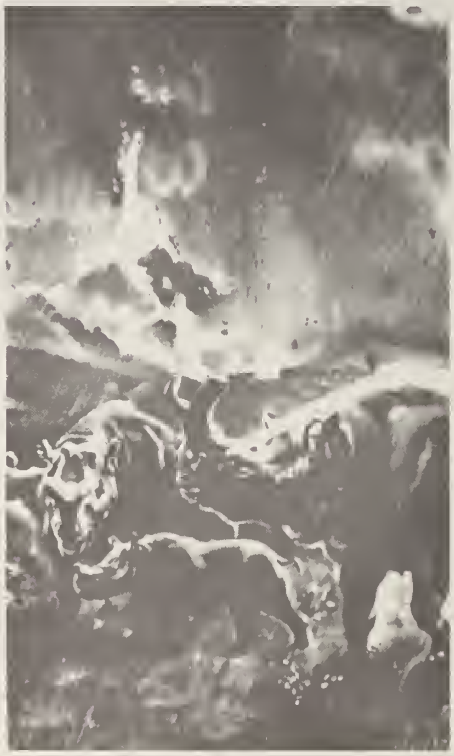


BRONTOTHERE TOOTH, *PALEOSYOPS*

BRONTOTHERE PELVIS, SPECIES INDETERMINATE



RECONSTRUCTED BRONTOTHERE, *TITANOTHERE*
(AT AMERICAN MUSEUM OF NATURAL HISTORY)



BRONTOTHERE RESTORATION

FIGURE VI-10 BRONTOTHERES

Fossil mammals permit the greatest dating precisions in Cenozoic age strata. Radiometric dating is very limited in sedimentary rocks. A set of mammal ages was worked out for the Cenozoic of North America (similar sets based on different mammals has or is being worked out for other continents). These are subdivisions of time which are chronologically more refined than those based on other means. The North American mammal ages for the latter half of the Eocene are based on mammalian fossils from the Uinta Basin

Twenty-one sites located during the present investigation were found to be significant in terms of indicating changes in the environment. The significant sites are indicated in Table VI-3. The fossils that have been identified show clearly the environmental changes that occurred from the deposition of the Green River Formation to that of the Uinta Formation. High concentrations of insect larvae and numerous reed imprints are highly suggestive of lake deposits that are typical of the Green River Formation. The overlying Uinta Formation includes stream-dwelling brontotheres, which reflects an environmental change from the underlying lake deposits, as indicated also by the lithology.

Although the most well-preserved fossil plant localities in the Green River Formation have been found outside the project area, significant deposits of fossil plants may occur within the tracts. Fossil insects, which have been found in high concentrations, have not been as extensively studied as other groups in paleontology. Information from these fossils is potentially very important to studies of paleoecology, paleoclimatology, and evolution.

The presence of several types of brontotheres is considered significant, especially because of their abundance and good state of preservation. Because they occur throughout a few hundred meters of strata, it is possible that evolutionary changes can be detected. Previous work in this area was incomplete, and additional academic studies are needed, especially since other mammals are probably present in this part of the Uinta Formation.

The present paleontological survey has provided additional fossil specimens of scientific value that otherwise might not have been found for some time, and it is certain that future academic studies of the important fossil sites will provide valuable specimens. It is possible that the insect and brontothere fossils might be significant enough for inclusion in a history inventory such as a national or state landmark; however, additional field work would be necessary to determine this.

5. WORK SCHEDULED

No further work is scheduled for the paleontological resources as part of the environmental baseline monitoring program. Mitigation measures to protect or recover significant on-tract fossil sites prior to project construction are being developed in the Detailed Development Plan.

REFERENCES

CULTURAL RESOURCES

Ambler, J. Richard

1966a Caldwell Village and Fremont Prehistory. Doctoral dissertation, University of Colorado. Boulder.

1966b Caldwell Village. University of Utah Anthropological Papers, No. 84. Salt Lake City. 118 pages, including appendices.

Breternitz, David A.

1970a Archeological Excavations in Dinosaur National Monument, Colorado-Utah, 1964-1965. University of Colorado Studies, Series in Anthropology, No. 17. Boulder.

Brew, John O.

1946 Archaeology of Alkali Ridge, Southeastern Utah. Papers of the Peabody Museum of American Archaeology and Ethnology, Harvard University, Vol. 21. Cambridge.

Burgh, Robert F.

1950 A Fremont Basketmaker in Dinosaur National Monument. Tree-Ring Bulletin, 16 (3):19-20. Tucson.

Burgh, Robert F. and Charles R. Scoggin

1948 The Archaeology of Castle Park, Dinosaur National Monument. University of Colorado Studies, Series in Anthropology, No. 2. Boulder.

Day, Kent C.

1964 Thorne Cave, Northeastern Utah: Archaeology. American Antiquity, Vol. 20, No. 1, pp. 50-59. Salt Lake City.

Dick, Herbert W.

n.d. The Archaeology of Marigold's Cave, Castle Park, Dinosaur National Monument. Unpublished manuscript on file, University of Colorado Museum. Boulder.

Gunnerson, James H.

1957 An Archeological Survey of the Fremont Area. University of Utah Anthropological Papers, No. 28. Salt Lake City.

1969 The Fremont Culture: A Study in Culture Dynamics on the Northern Anasazi Frontier. Papers of the Peabody Museum of Archaeology and Ethnology, Harvard University, Vol. 59, No. 2. Cambridge.

Johnson, Alfred E.
1974 Settlement Pattern Variability in Brush Creek Valley, Platte County, Missouri. Plains Anthropologist, Vol. 19, No. 64. Topeka.

Kehoe, T.F.
1966 The Small Side - Notched Point System of the Northern Plains. American Antiquity, Vol. 31, No. 6. Salt Lake City.

Leach, Larry L.
1966 The Archeology of Boundary Village, University of Utah Anthropological Papers, No. 83, Miscellaneous Collected Papers, No. 13. Salt Lake City. pp. 85-129.

1970 Archeological Investigations at Deluge Shelter (42Un1). Ph.D. dissertation, on file, University of Colorado. Boulder.

Lister, Robert H.
1951 Excavations at Hells Midden, Dinosaur National Monument. University of Colorado Studies, Series in Anthropology, #3. Boulder.

Madsen, David B. and Michael S. Berry
1975 A Reassessment of Northeastern Great Basin Prehistory. American Antiquity, Vol. 40, No. 4. Washington.

Marwitt, J.P.
1970 Median Village and Fremont Culture Regional Variation. University of Utah Anthropological Papers, No. 95. Salt Lake City.

Morris, Earl H.
1939 Archaeological Studies in the La Plata district, southwestern Colorado and northwestern New Mexico - with an appendix, "Technology of La Plata Pottery," by A.O. Shepard. Carnegie Institution of Washington, Publication 519. Washington.

Morss, Noel
1931 The Ancient Culture of the Fremont River in Utah. Papers of the Peabody Museum of American Archaeology and Ethnology, Harvard University, Vol. 12. Cambridge.

Schaafsma, Polly
1971 The Rock Art of Utah. Papers of the Peabody Museum of Archaeology and Ethnology, Harvard University, Vol. 65. Cambridge.

Sharrock, Floyd. W.
1966 Prehistoric Occupation Patterns in Southwest Wyoming and Cultural Relationships with the Great Basin and Plains Culture Areas. University of Utah Anthropological Papers, No. 77. Salt Lake City.

Shields, Wayne F.
1967 1966 Excavations: Uinta Basin. University of Utah Anthropological Papers, No. 89, Miscellaneous Papers, No. 15, pp. 1-30. Salt Lake City.

Wormington, H. Marie and Robert H. Lister
1956 Archaeological Investigations of the Uncompahgre Plateau. Proceedings of the Denver Museum of Natural History, No. 2. Denver.

REFERENCES

PALEONTOLOGICAL RESOURCES

Carpenter, F.M., 1955. An Eocene Bittacus (Mecoptera) [Utah]; Psyche, V. 62, No. 1, p. 39-41.

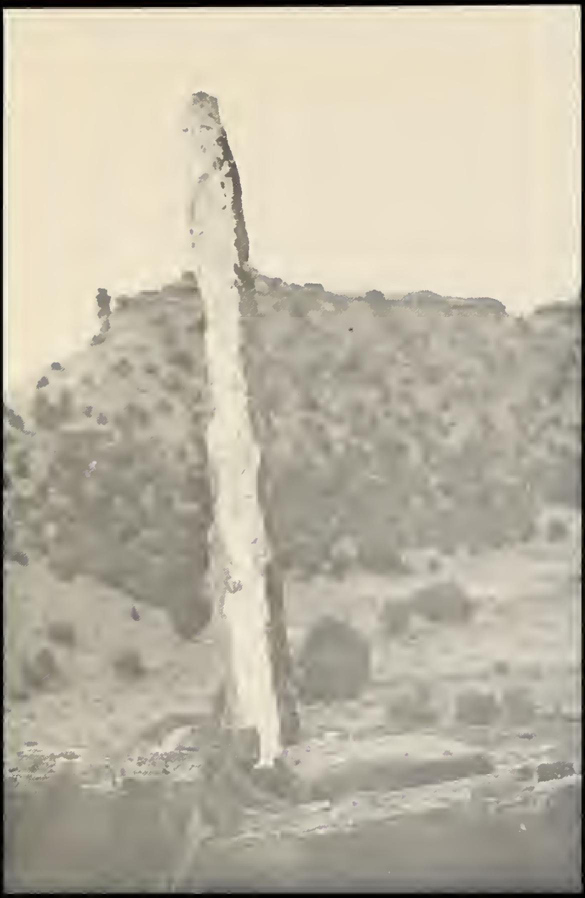
Knowlton, F.H., 1923. Revision of the flora of the Green River Formation; U.S. Geol. Surv. Prof. Paper 131, pp. 133-182.

MacGinitie, H.D., 1969. The Eocene Green River flora of northwestern Colorado and Northeastern Utah; California University Publ. Geol. Sci., V. 83, pp. 1-203.

Scudder, S.H., 1877. The first discovered traces of fossil insects in the American Tertiaries; U.S. Geol. and Geog. Surv. Terr. (Hayden), V. 3, pp. 741-762.

Scudder, S.H., 1890. The Tertiary Insects of North America; U.S. Geol. Surv. of the Terr. (Hayden in charge), V. 13, pp. 1-734.

Scudder, S.H., 1892. Some insects of special interest from Florissant, Colo., and other points in the Tertiaries of Colorado and Utah; U.S. Geol. Surv., V. 93, pp. 1-35.



VII
AESTHETICS

VII. AESTHETICS

A. OBJECTIVES

The aesthetic qualities of an area are influenced by land use, vegetation, topography, climate, geology, wildlife, and hydrology. Each person perceives these qualities differently, depending on individual interpretations of sight, sound, smell, touch, and taste. These perceptions are moderated by emotional, cognitive, and evaluative responses. The principal users of the project area will be employees of the project, local residents, and tourists visiting the area for various recreational pursuits (e.g., hunting, fishing, rockhounding, river rafting).

B. METHODOLOGY

Aesthetic resources were defined in terms of landscape units. A landscape unit is an area of land with common distinguishing visual characteristics in the landform, rock formations, water forms, and vegetative patterns. The four elements competing for dominance in any landscape are form, line, color, and texture. Man-made deviations to landscape units can be either "positive" or "negative," depending on the degree of contrast to the characteristic landscape.

C. SUMMARY OF RESULTS

1. REGIONAL AREA

The boundary landforms around the Uinta Basin are the primary aesthetic resources of the region. The most accessible of these are the Uinta Mountains, the Book Cliffs, the Wasatch Plateau, Flaming Gorge National Recreation Area, Dinosaur National Monument, and the Green River. The landscapes are diverse, from the glacier-scoured Uinta Mountains to the river-cut Split Mountain in Dinosaur National Monument. The area is known as "red rock country," indicating the dominant color perception. Atmospheric conditions that influence the perception of aesthetic resources in the region are dust, daily extremes in temperature, and dryness.

2. TRACTS U-a AND U-b

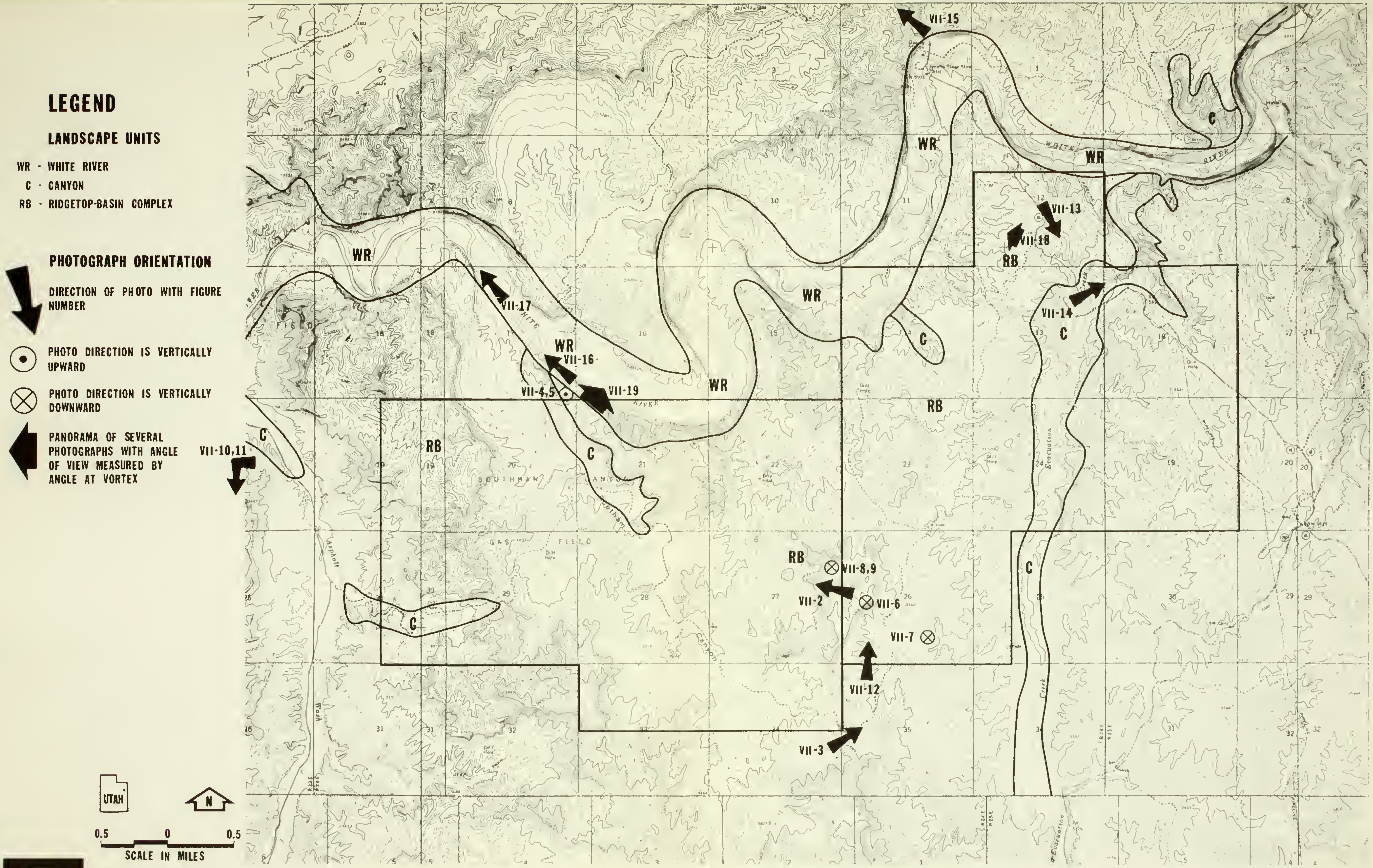
Tracts U-a and U-b and a 1.6-km (1-mi) border area were divided into mappable landscape units. The perceptual input from natural and man-made aesthetic resources were compared for each unit. Three landscape units were defined: the ridgetop basin unit, the canyon unit, and the White River unit. These units will be considered separately. The three units are shown in Figure VII-1.

a. The Ridgetop-Basin Landscape Unit

The ridgetop-basin complex includes areas with "superior" views (when the observer is above the surrounding landscape). (See Figures VII-2 and VII-3.) The most distinct views are from the ridges serving as drainage divides between Asphalt Wash and Southam Canyon and Southam Canyon and Evacuation Creek and from the ridges overlooking tributary basins to the White River. These areas afford spectacular panoramic views that reveal the contrast between the brown-to-buff-colored Uinta Formation and the underlying Green River Formation and its numerous strata, which give a horizontal linear pattern to the light-gray unit. The views are so distant that the aesthetic experience is primarily visual. The views are highlighted at sunrise, when individual buttes and ridge walls are lit up, and at sunset, when the canyons are in shadow (see Figures VII-4 and VII-5).

In contrast, the setting on the ridgetops is dominated by unusual micro-landforms like lichen, ancient ripple marks, precipitation cusps in rock, honeycombed appearance of some calcareous rock, and seedling pinyon trees (see Figures VII-6 through VII-9). Numerous rock pinnacles, waterpockets, balanced rocks, and rock windows are the most prominent unique geologic features (see Figures VII-10 and VII-11). These include Castle Rock and Duck Rock, which are accessible from the main improved dirt road that runs from Ignacio Bridge to Southam Canyon (see Figures VII-12 and VII-13). The environment on the ridgetops is usually quiet, and the visibility is usually excellent. Water pockets form in shallow rock depressions on the mesa tops and give added diversity to the landscape. Most areas in this unit are accessible by short hikes from the improved direct roads or by driving directly over a drainage divide like the road from Southam Canyon to Asphalt Wash.

Lizards, snakes, mourning doves, deer, cottontail rabbits, and antelope ground squirrels are often seen, as are soaring raptors such as the red-tailed hawk in summer and the golden eagle in winter, spring, and summer.



LANDSCAPE UNITS & PHOTOGRAPH ORIENTATIONS FOR EVALUATING AESTHETIC RESOURCES

FIGURE VII-1

FIGURE VII-2

(PLUS-X, 1/250, F.11, F.L. inf.)

SOUTHAM CANYON

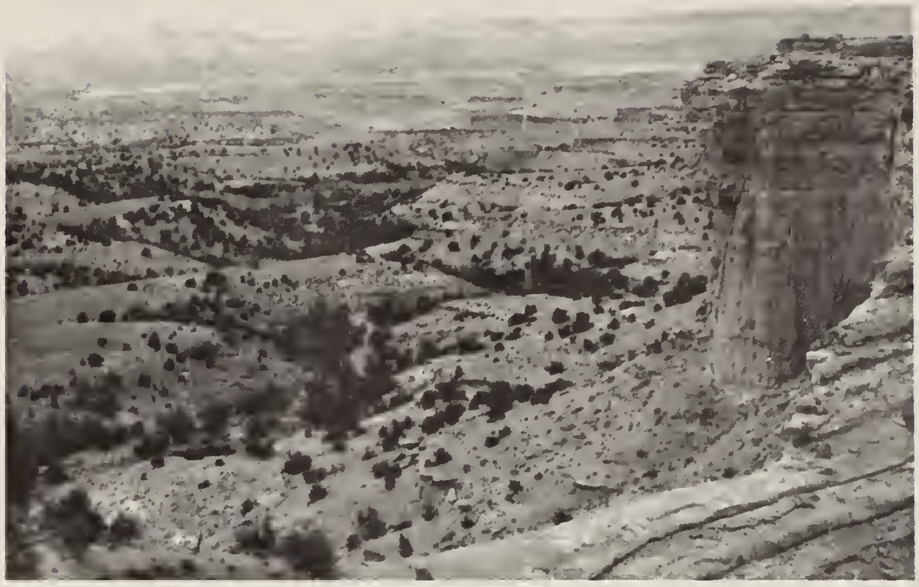
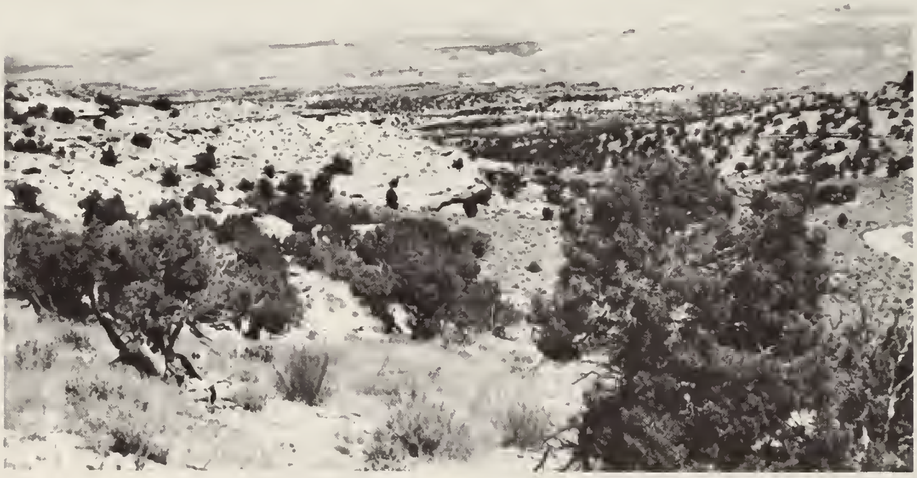


FIGURE VII-3

(PLUS-X, 1/500, F.16, F.L. inf.)

RIDGETOP VEGETATION



THESE ARE PANORAMIC VIEWS CHARACTERISTIC OF THE RIDGETOP-BASIN LANDSCAPE UNIT. THE TOP PHOTO WAS TAKEN ON THE RIDGE OVERLOOKING SOUTHAM CANYON, WHILE THE LOWER PHOTO DEMONSTRATES THE SPARSENESS OF VEGETATION, A FACTOR THAT GIVES GREATER EMPHASIS TO GEOLOGIC FEATURES. REFER TO FIGURE VII-1 FOR EXACT LOCATION OF PHOTOGRAPHER POSITION AND DIRECTION OF AIM FOR ALL PHOTOS.

FIGURE VII-4
(PLUS-X, 1/30, F. 2, F.L. inf.)
SUNRISE

FIGURE VII-5
(PLUS-X, 1/30, F. 2, F.L. inf.)
SUNRISE

THESE ARE PHOTOS OF THE SUNRISE TAKEN FROM A RIDGETOP OVERLOOKING THE WHITE RIVER. CLOUD PATTERNS ARE FREQUENTLY DIVERSE AND WIDESPREAD IN THE EARLY MORNING.

FIGURE VII-6

(PLUS-X, 1/125, F.6, F.L. 3m.)

PINYON TREE

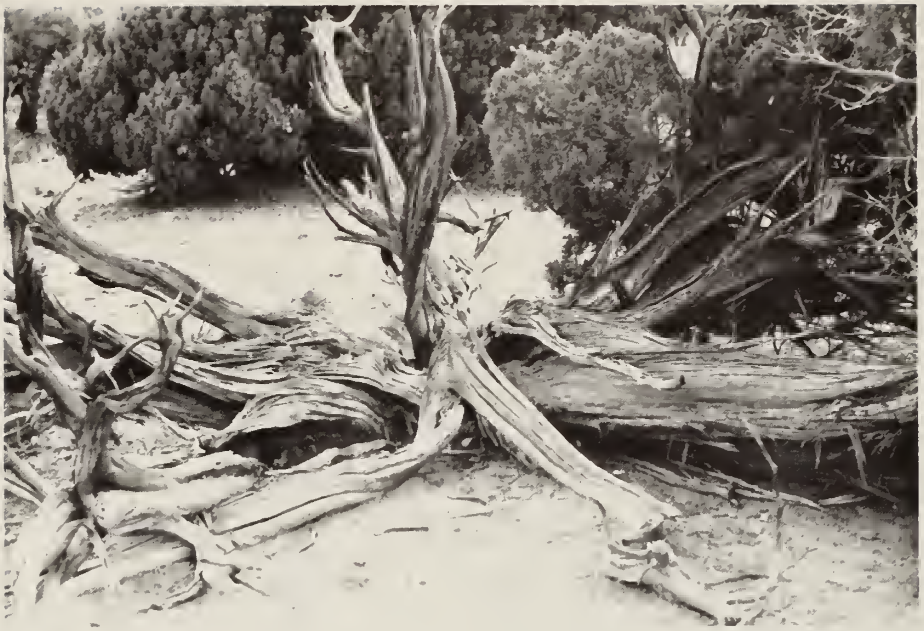
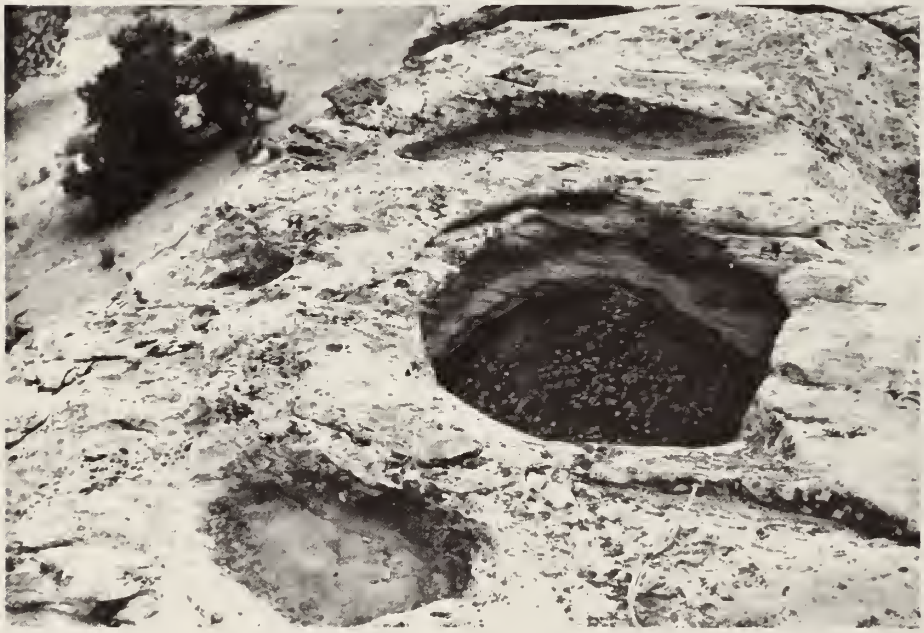


FIGURE VII-7

(PLUS-X, 1/125, F. 8, F.L. 3m.)

WATERPOCKETS



THESE PHOTOS ILLUSTRATE THE UNIQUE DETAIL PREVALENT ON RIDGETOPS AND SUPPLEMENTING THE PANORAMIC VIEWS. THE TOP PHOTO IS A PINYON TREE SPLIT BY LIGHTNING, AND THE BOTTOM PHOTO IS AN EXAMPLE OF THE WATERPOCKETS THAT ADD WATER, A RARE ELEMENT OF THE LANDSCAPE.

FIGURE VII-8
(PLUS-X, 1/250, F.2, F.L. 0.8m.)

GEOLOGIC DETAIL

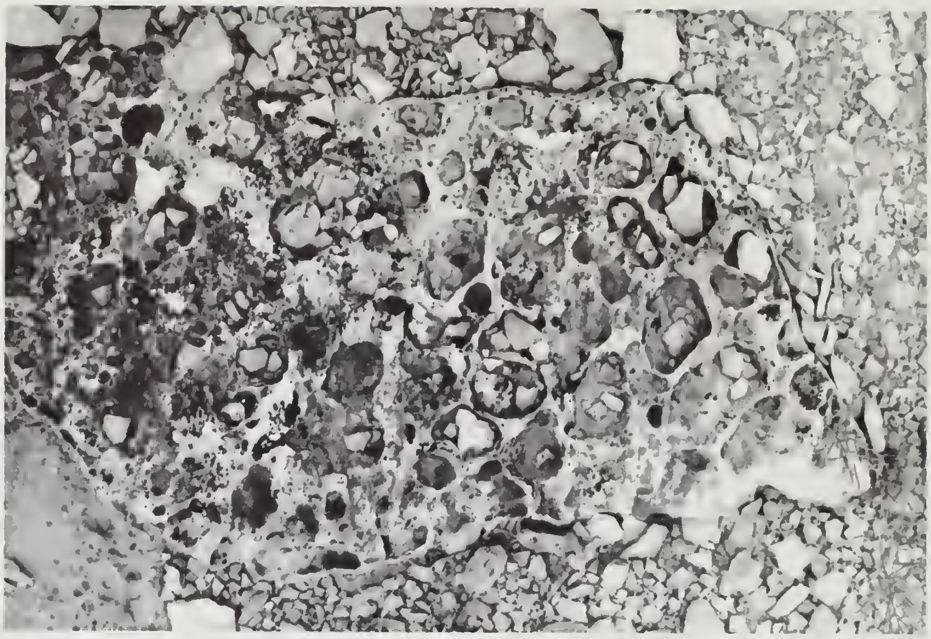
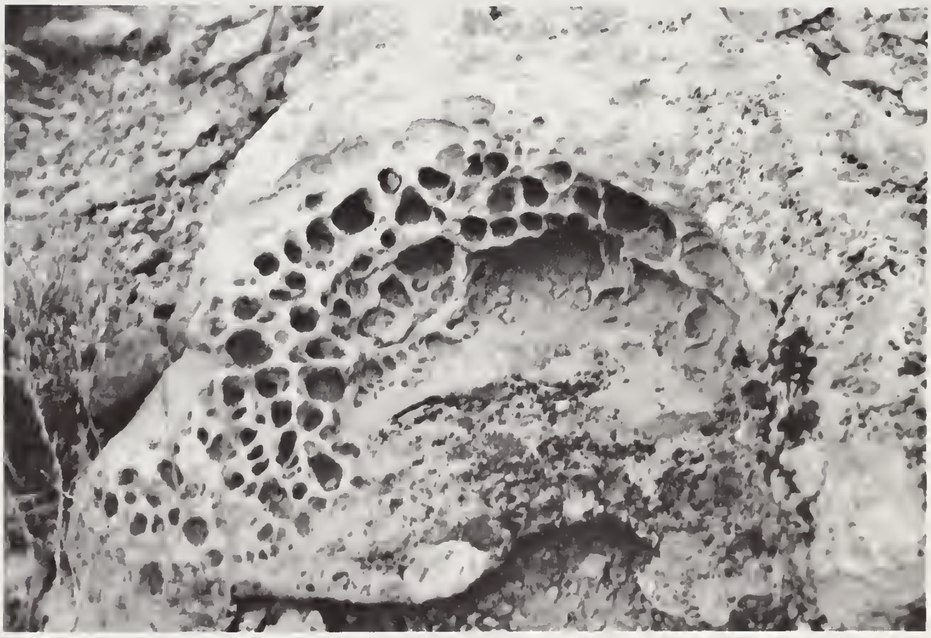


FIGURE VII-9
(PLUS-X, 1/250, F.2, F.L. 0.8m.)

GEOLOGIC DETAIL



THESE TWO PHOTOS TAKEN ON THE RIDGETOP OVERLOOKING SOUTHAM CANYON PROVIDE FURTHER EXAMPLES OF THE DETAIL IN GEOLOGIC DESIGN.

FIGURE VII-10
(PLUS-X, 1/125, F. 6, F.L. inf.)
BALANCED ROCK

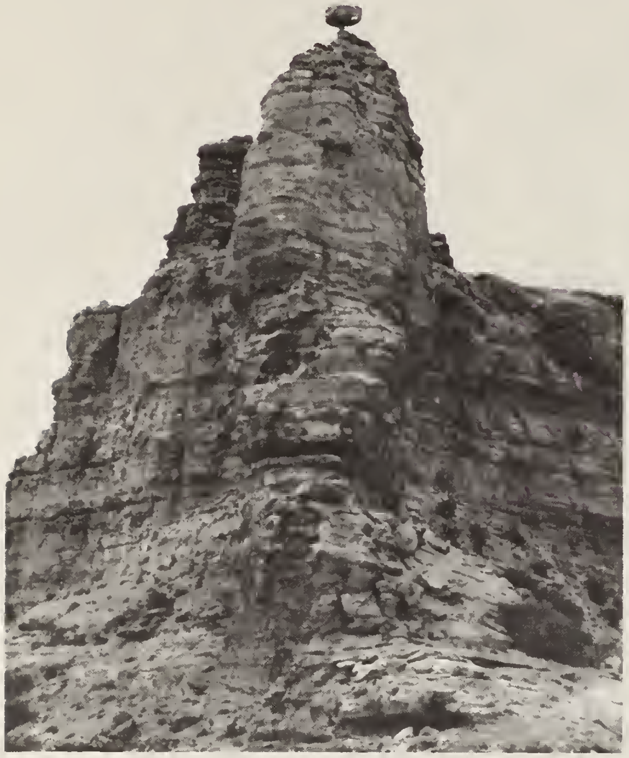
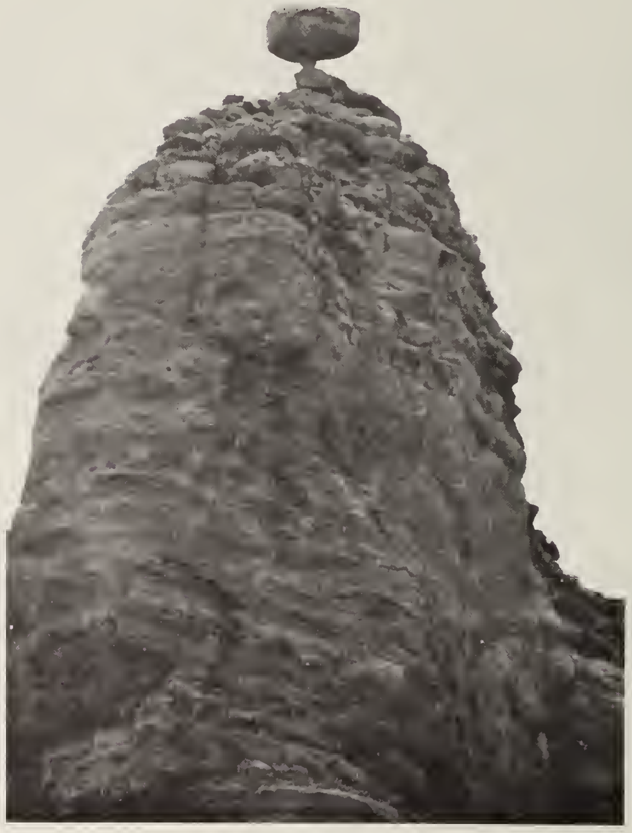


FIGURE VII-11
(PLUS-X, 1/125, F. 6, F.L. inf.)
BALANCED ROCK



THESE TWO PHOTOS SHOW BALANCED ROCK AT TWO SCALES. THE ROCK IS A VISUAL HIGHLIGHT TO THE WEST RIDGE OF ASPHALT WASH, CONSISTING OF A ROCK APPROXIMATELY 3M BY 3M BY 2M (9.8 FT X 9.8 FT X 5.6 FT) SUPPORTED BY A BOULDER THE SIZE OF A SMALL WATERMELON.

FIGURE VII-12
(PLUS-X, 1/250, F.8, F.L. 10m.)
ROCK WINDOWS

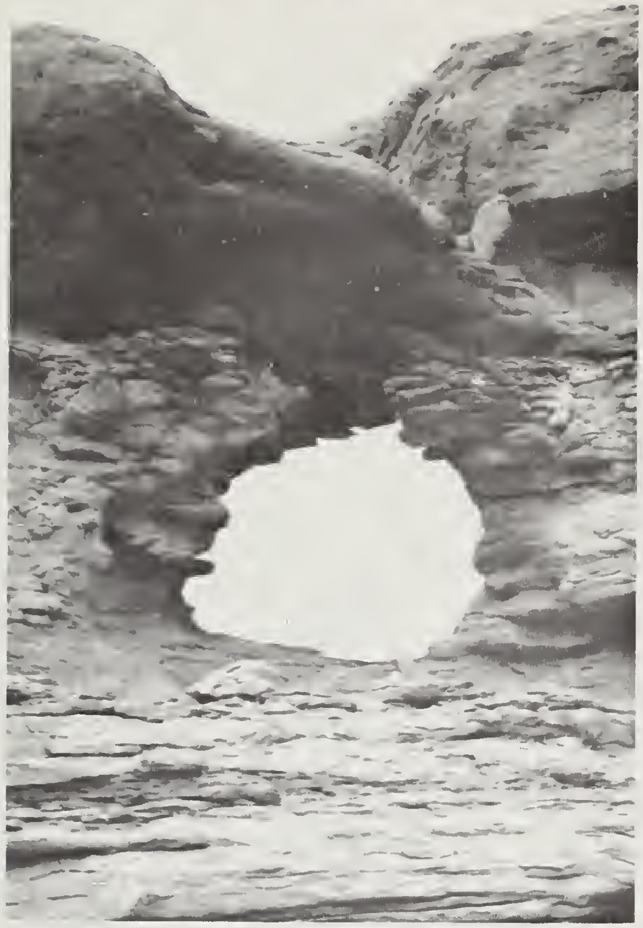
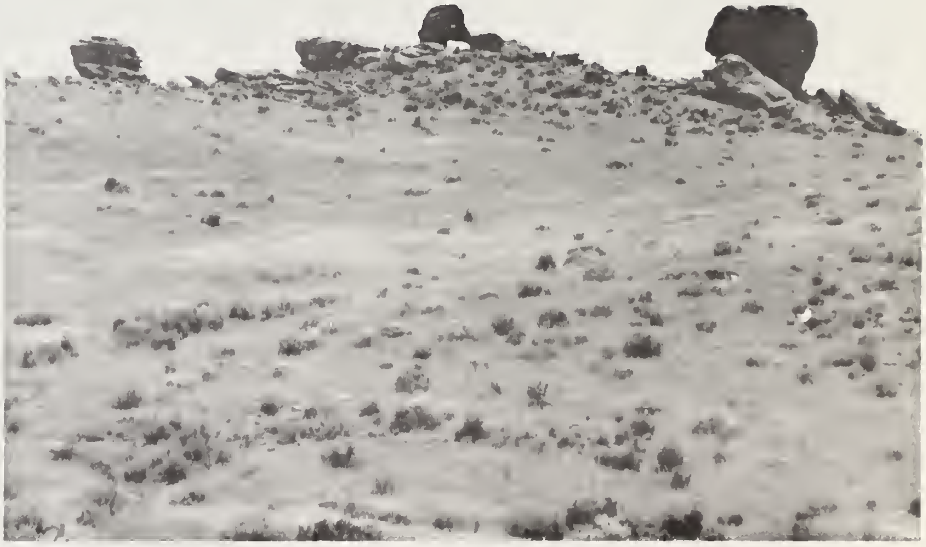


FIGURE VII-13
(PLUS-X, 1/250, F. 16, F.L. inf.)
DUCK ROCK



ROCK WINDOWS ARE A CONTRAST TO THE LAND/SKY INTERFACE, AS ILLUSTRATED BY THE WINDOW (ABOVE) FOUND IN THE SOUTHEAST CORNER OF TRACT U-b, AND BY DUCK ROCK (BELOW), WHICH IS VISABLE FROM THE EXISTING DIRT ROAD (UTAH HIGHWAY 45) ENTERING TRACT U-a SOUTH OF IGNACIO STAGE STOP.

b. The Canyon Landscape Unit

The canyon areas include Evacuation Creek, lower Southam Canyon, Asphalt Wash, and all steep-walled tributaries to these drainages and to the White River. Because the water-land interface is such a dominant element in the White River canyon, this area will be considered separately. The canyon landscape unit is characterized by enclosed views enhanced by geologic detail, micro-changes in vegetation, and water in ephemeral stream courses. (See Figures VII-14 and VII-15.) A variety of unusual cavities and swallow nests along the rock walls below the protruding ledges associated with the Green River Formation give Evacuation Creek canyon a coarse, honey-combed appearance. The bird's nest aquifer outcrops here, and many birds have built nests in the cavities. Soaring birds are occasionally seen gliding with the mid-morning convective wind currents far above the canyon walls.

The nearly vertical walls focus attention in the canyon and along the sharp boundary between the walls and the usually clear Utah sky. The canyons meander with the stream channel; this is accentuated toward their downstream portions, which decreases the length of the view and focuses attention on detail. A distinctive white bed of volcanic ash with a sandstone texture is visible along the walls of Evacuation Creek. Quicksand is encountered in the creekbed where the bird's nest aquifer discharges water into the stream's sandy alluvium. Bubbles of relatively clear ground water boil up through the sand or along the edge of the creekbed and form pools, in extreme contrast to the turbid stormflow subsequent to summer thunderstorms and spring runoff. Desert varnish, composed of the reds, blues, and blacks of oxides of iron and manganese, gives a tapestried appearance to canyon walls and overhanging ledges. Mudflows have also streaked the walls.

In contrast to Southam Canyon, Asphalt Wash, and tributaries to the White River, Evacuation Creek has more confined views, more frequent streamflow, and more vegetation types, including the more colorful riparian associations. Southam Canyon has fewer enclosed views, and Asphalt Wash has fewer meanders and is in a more symmetrical valley.

c. The White River Landscape Unit

Since the White River is the most prominent feature and the only perennial stream on Tracts U-a and U-b within a 1.6-km (1-mi) radius, it is considered as a separate landscape unit. Although the views are characteristically enclosed within canyon walls, considerable detail and movement can be observed from the river itself. (See Figures VII-16 and VII-17.) The canyon walls are steep and in places are composed of stream-cut facets with large vertical relief and vertical joint and fracture lines superimposed on the horizontal bedding stratifications. The land-water interface along the river is a continuation of point bars protruding from the canyon walls and cut banks on the opposite side of the river. Thinly laminated silt beds on the bars and alluvial deposits of various sizes are exposed on the cut banks as a cross-section of the river's history. Rock ledges, rock windows, rock alcoves, and recent rockfalls are common. The highest ridge visible from the river is in sharp, jagged contrast with the sky. (See Figures VII-18 and VII-19.)

Channel bars, snags, and driftwood are common in the river. Beaver caches and their builders are sometimes seen. Lower point bars show evidence of meander scars, which emphasize the sinusoidal nature of the channel pattern. The more stable point bars are thickly vegetated with green cottonwoods. Cattle frequently occupy these riparian areas, and deer are occasionally seen, particularly east of Ignacio Bridge.

Numerous insects, lizards, and snakes which appear frequently along the stream banks attract the observer's attention. Ducks, Canada geese, various shorebirds, and soaring raptors add to the aesthetic setting. Dilapidated cabins that once belonged to shepherds are visible from the river 3 km (2 mi) downstream at Ignacio Bridge. An abandoned oil shale mine and trestle are visible between the mouths of Hells Hole Canyon and Evacuation Creek on the north side of the river. Although the river is extremely turbid, reflections of sunlight can often be seen from the bridge or from the riffles during sunrise. At sunset, long shadows on the river emphasize ridgeform and vegetation shapes.

Two seasonal aspects of the aesthetic are especially evident along the White River. In the winter, the river freezes and forms a white band of ice that winds through the canyon. In the fall, some of the riparian vegetation turns red, orange, and yellow and contrasts with evergreen shrubs and trees.

D. CONCLUSIONS

The Uinta Basin and Tracts U-a and U-b are characterized by a variety of aesthetic resources. The landforms surround-

FIGURE VII-14
(PLUS-X, 1/125, F. 11.5, F.L. inf.)
EVACUATION CREEK

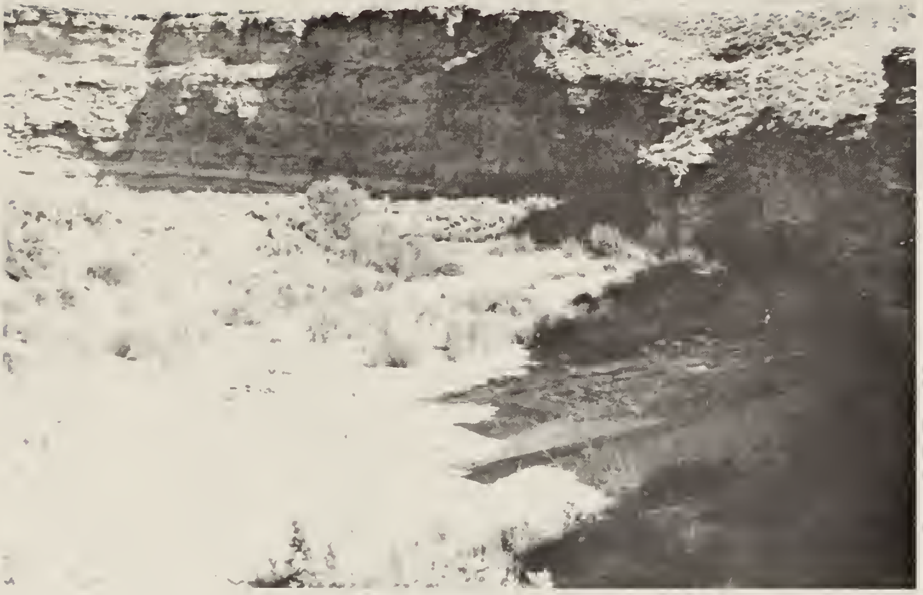
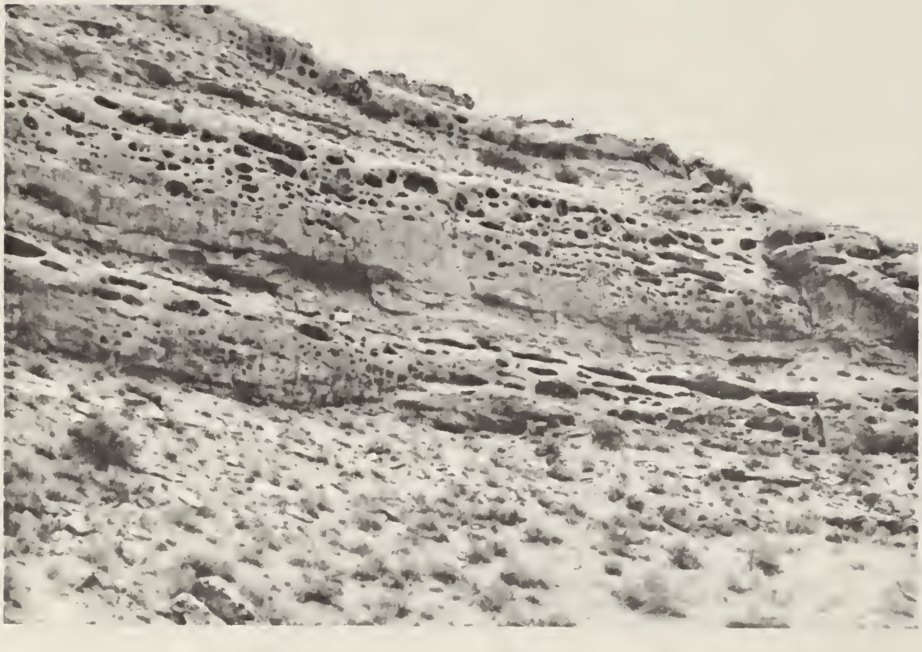


FIGURE VII-15
(PLUS-X, 1/125, F. 14, F.L. inf.)
CANYON WALL CAVITIES



THESE TWO ENCLOSED VIEWS ARE CHARACTERISTIC OF THE CANYON LANDSCAPE UNIT. THE TOP PHOTO IS LOOKING EAST, FACING DOWNSTREAM ON EVACUATION CREEK, AND THE LOWER PHOTO, TAKEN ALONG THE ACCESS ROAD ENTERING TRACT U-a, IS AN EXAMPLE OF THE NUMEROUS CAVITIES FOUND ON CANYON WALLS.

FIGURE VII-16
(PLUS-X, 1/250, F. 16, F.L. inf.)
WHITE RIVER

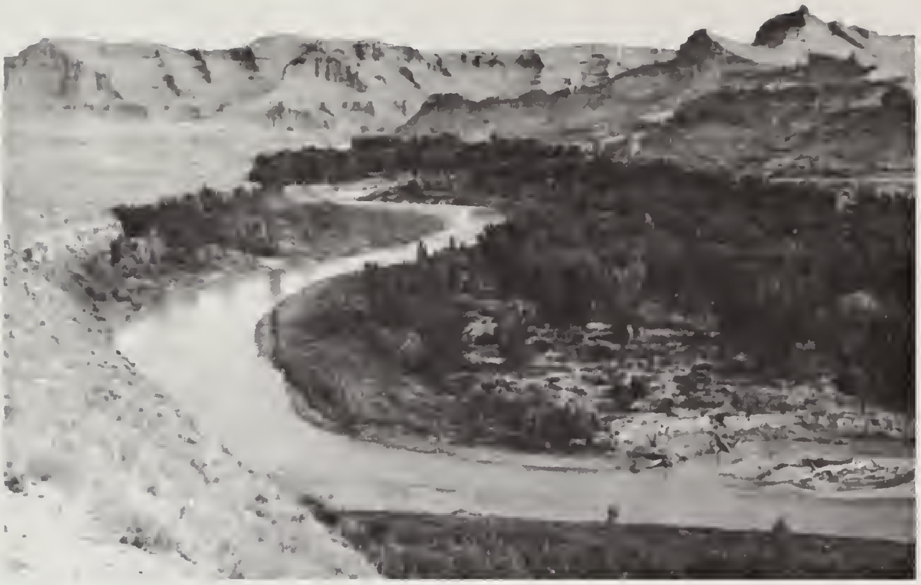
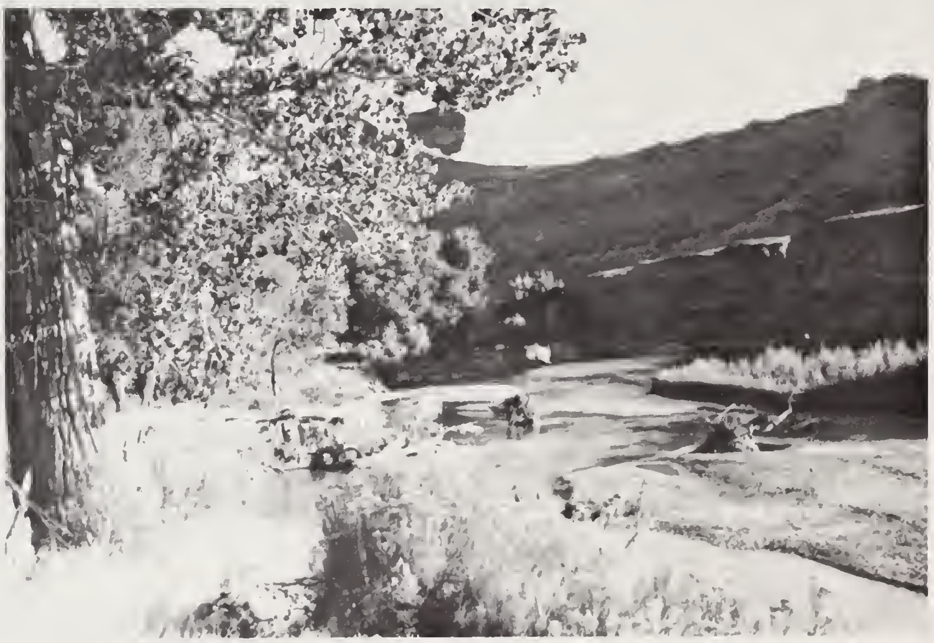


FIGURE VII-17
(PLUS-X, 1/250, F. 16, F.L. inf.)
WHITE RIVER VEGETATION



THESE TWO VIEWS ARE COMMON IN THE WHITE RIVER LANDSCAPE UNIT, ILLUSTRATING THE ARRAY OF FLUVIAL LANDFORMS AND CONTRAST IN VEGETATION TYPES.

PANORAMIC VIEWS OF THE WHITE RIVER PROVIDE THE MOST UNIQUE, CONTRASTING, AND DIVERSE SETTINGS FOR INDIVIDUAL PERCEPTION OF AESTHETIC RESOURCES. THE LAND/SKY INTERFACE IS SHARP AND SUCH VIEWS CONSTITUTE EXCELLENT OBSERVATION POINTS WHEN SEARCHING FOR RAPTORS, LARGE MAMMALS, AND OTHER WILDLIFE OF AESTHETIC INTEREST. COLOR AND FORM ARE THE DOMINANT ELEMENTS IN THESE PANORAMAS, WHICH ENCOMPASS VIEWS OF 55° AND 175°.

FIGURE VII-18
(PLUS-X, 1/500, F. 16, F.L. inf.)

FIGURE VII-19
(PLUS-X, 1/125, F. 12, F.L. inf.)

ing the basin--the Uinta Mountains, the Book Cliffs, the Wasatch Plateau, and the Green River--are the primary and most accessible features. Although the tracts are a harsh, arid environment subject to climatic extremes, they nevertheless contain an abundance of unusual and interesting aesthetic features. Elevated landforms and clear air afford spectacular panoramic views devoid of human influence. The many unique geologic formations set against the clear Utah sky include rock windows, balanced rocks, odd rock shapes, monoliths, and multi-patterned canyon walls. Closer inspection of many of these formations reveals micro-landforms and patterns. The White River and its lush riparian areas are a contrast to the sparsely-vegetated desert.

The tracts were divided into three distinct landscape units--the ridgetop-basin complex, the canyons, and the White River. The most pleasing feature of the ridgetop-basin-unit is the spectacular panoramic views of the surrounding landscape and the unique geologic features that can be seen from the ridgetops. The ridgetops themselves are characterized by unusual micro-landforms.

The canyon areas include Evacuation Creek, lower Southam Canyon, Asphalt Wash, and all steep-walled tributaries to these drainages and to the White River. The landscape is characterized by vegetation, water in ephemeral streams, and unusual geologic detail such as the protruding ledges of the Green River Formation and the nahcolite formations of the bird's nest aquifer outcrops.

The White River, the only perennial stream on the tracts, is enclosed within canyon walls. The thick vegetation and cottonwood trees along the river are often occupied by cattle. These riparian areas are a pleasing contrast to the sparse vegetation and stark geological detail of the surrounding area.

In summary, no one landscape unit as described can be designated more aesthetically sensitive than the other. The oil-shale tracts and the region surrounding them are diverse and unique, and any areas proposed for commercial development (i.e., retort site, spent shale disposal site, roads, power lines, etc.) should be judged individually or collectively to fully evaluate the aesthetic impact or significance.

E. WORK SCHEDULED

The aesthetic resources inventory has been completed, and no work is scheduled for the second year of environmental baseline monitoring.

Form 1279—3
(June 1984)

BORROWER'S

TN 859 .U82 W4185 197

First year environmen
baseline report

DATE LOANED	BORROWER

USDI — ELM